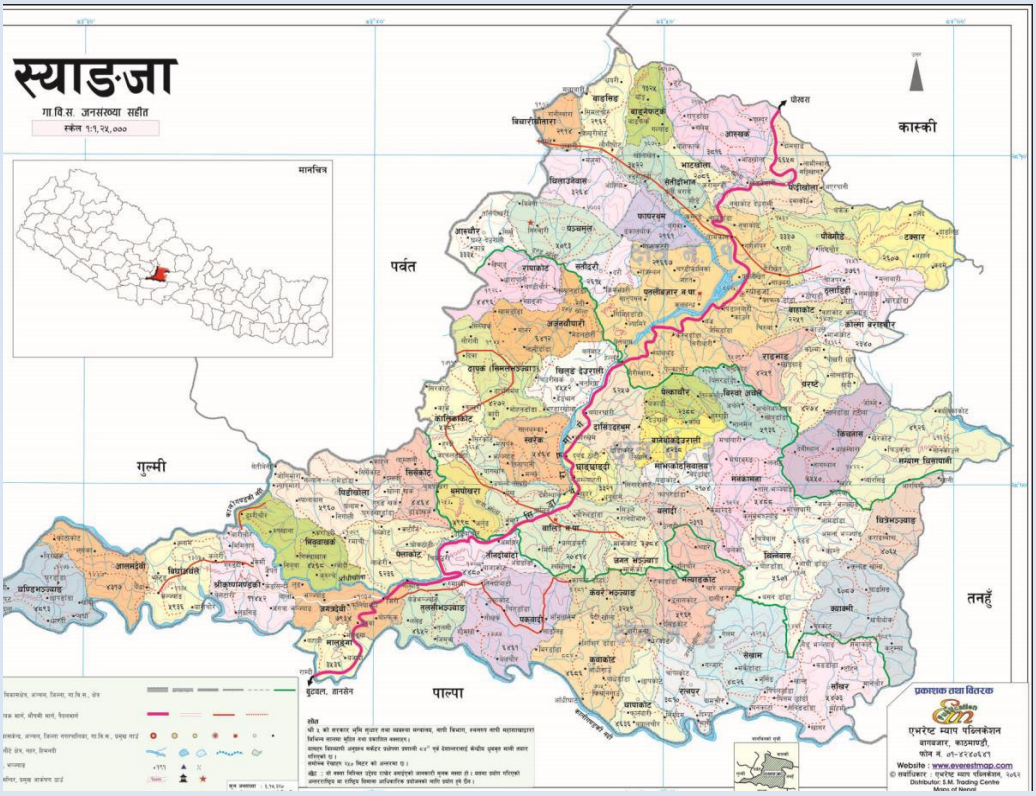
GOVERNMENT OF NEPAL
MINISTRY OF PHYSICAL INFRASTRUCTURE & TRANSPORT
DEPARTMENT OF ROADS
PLANNING AND DESIGN BRANCH
PLANNING MONITORING AND EVALUATION UNIT
CHAKUPAT LALITPUR

March, 2018

Final Report

DETAIL ENGINEERING SURVEY, DETAILS DESIGN OF ROADS AND REPORT PREPARATION OF "KADKHETARI PANCHESE DOBILLA SADAK, SYANGJA"

CONTRACT NO. PMEU/337159/073/74 DPR-4



MAIN REPORT
VOLUME I

Submitted By:

GOEC Nepal Pvt. Ltd.
Buddhanagar, Kathmandu
Ph: 01-4783060, Fax:
Email: goecnepal10@gmail.com

DATA SOURCES AND CREDITS

Government of Nepal
Ministry of Physical Infrastructure & Transport,
Department of Roads,
Planning and Design Branch
Planning Monitoring and Evaluation Unit
Chakupat, Lalitpur

Final Report

March,2018

This document is the Final report prepared for the project, "Detail Engineering Survey, Details Design of Roads and Report Preparation of Khadketari Panchase Dobilla Sadak, Syangja", undertaken by Government of Nepal, Ministry of Physical Infrastructure & Transport, Department of Roads, Planning and Design Branch, Planning Monitoring and Evaluation Unit, Chakupat, Lalitpur. This document has been prepared by GOEC NEPAL PVT. LTD, Buddhanagar, New Baneshwor, Kathmandu, Nepalfor Department of Roads.The opinions, findings and conclusions expressed herein are those of the Consultant and do not necessarily reflect those of Department of Roads.

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Data Sources and Credits

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PROJECT INFORMATION

Name of the Project	Detail Engineering Survey, Details Design of Roads and Report Preparation of Khadketari Panchase Dobilla Sadak, Syangja
	CONTRACT NO. PMEU/337159/073/74 DPR-4
Project Executive Agency	Government of Nepal
	Ministry of Physical Infrastructure & Transport
	Department of Roads
	Planning and Design Branch
	Planning Monitoring and Evaluation Unit
	Chakupat, Lalitpur
Implementating Agency	Government of Nepal
	Ministry of Physical Infrastructure & Transport,
	Department of Roads,
	Planning and Design Branch
	Planning Monitoring and Evaluation Unit
	Chakupat, Lalitpur
Name of the consultant	GOEC NEPAL PVT. LTD.
	Buddhanagar, Kathmandu
Project Commencement Date	2074

SUBMISSION INFORMATION		
Name of the Report	Detail Engineering Survey, Details Design of Roads and Report Preparation of Khadketari Panchase Dobilla Sadak, Syangja	
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Checked By		
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This report has been prepared as per the contract between Postal Highway Project, Department of Roads as the Client and the GOEC NEPAL PVT. LTD, Buddhanagar, Kathmandu, Nepal, as the Consultant, as preparation of project reportof"Detail Engineering Survey, Details Design of Roads and Report Preparation of Khadketari Panchase Dobilla Sadak, Syangja". This report is submitted as Draft report in accordance with the given Terms of Reference (TOR).

This report is an outcome of systematic compilation of all relevant data collected during the desk study and data collected during field study as well as from the secondary sources as presented in various formats and drawings.

We would like to express our genuine gratitude towards the Postal Highway Project, Department of Roads for awarding this project. Also we would like to express our deep gratitude and sincere thanks to the division chief for providing us necessary guidance, relevant and useful concepts and encouragement, valuable suggestion and comments which was indeed an immense help for the successful completion of this project.

We would like to thank Divisional Road Office's staffs of Syangjadistrict for their sincere co-ordination, support, valuable guidelines and co-operation.

At last, we are grateful to all the local people, leaders of political parties, civil society and all the office colleagues who have rendered their valuable accompany to our team during execution of the works.

GOEC NEPAL PVT. LTD
Buddhanagar,Kathamandu

SYNOPSIS

This report has been prepared as per the contract between Planning Monitoring and Evaluation Unit, Department of Roads as the Client and the GOEC NEPAL PVT. LTD, Buddhanagar, Kathmandu, Nepal, as the Consultant, as preparation of project report of "Detail Engineering Survey, Details Design of Roads and Report Preparation of Khadketari Panchase Dobilla Sadak, Syangja". This report is submitted as Draft report in accordance with the given Terms of Reference (TOR).

This report consists of several chapters. For this purpose a multidisciplinary team of experts were engaged for carrying out desk, field and office studies as well as analysis of all available primary and secondary information and data pertaining to a variety of disciplines such as: topography, geomorphology, geology, geo-techniques, hydrology, sociology, demography, economy, traffics, agriculture, forestry, ecology, design and drawing of surveyed road of the area and districts. Study of the characteristics of the area to be influenced directly by the construction of the road was given due stress. All these studies helped to understand the project area in terms of physical models into which the task fitting the road in the most optimal fashion, without any potential adverse impact to environment.

Chapter 1 of the report highlights the general introduction, location of project, significance, connection with other road network and map study.

Chapter 2 of the report highlights the socio-economic profile of the influenced municipality and VDCs. It highlights change in demographic trend, land use pattern, utility services, economic activity, health, education, transport and communication network and administrative facilities.

Chapter 3 of the report highlights the traffic studies and design of pavement. It describes about present traffic data, present transportation mode and it's reliability, adjustment of traffic volume in comparison with increased population and production, traffic forecasts and projection, traffic safety and pavement design according to DCP test result.

Chapter 4 of the report highlights the detailed engineering survey. It describes about staff involved with survey works, procedure of survey activities, establishment of BM and IP points, geometric standard followed as per Nepal Road Standard 2070 for feeder road.

Chapter 5 of the report highlights the engineering study and inventory survey. It describes about road inventory survey, construction materials survey, geological and geo-technical survey, hydrological and meteorological studies of the studied road alignment.

Chapter 6 of the report highlights the design and drawings. It describes about the design parameters followed during design of road, about design software and preparation of drawings as mentioned.

Chapter 7 of the report highlights the environment study. It describes about benefits and impact on physical and biological environment due to road upgradation and recommends mitigating plans and measures.

Chapter 8 of the report highlights the preparation of detailed project report. It describes about detailed project cost estimate, rate analysis, quantity estimate, bill of quantities and summary of quantity and project cost.

Annexes of the report consist of following information:

Annex I : Topographic, Google, SRN and District Maps
Annex II : Photographs of Road Inventory Survey, DCP Test & Detailed Engg. Survey
Annex III : References

- BM and Station Data
- DCP Test Result
- Construction Material Test Result

ABBREVIATION

AADT	Average Annual Daily Traffic
ADT	Average Daily Traffic
ADB	Asian Development Bank
AMSL	Average Mean Sea Level
BCR	Benefit Cost Ratio
CDMA	Code Division Multiple Access
DDC	District Development Committee
DOR	Department of Roads
ECD	Early Childhood Development Centers
EIRR	Engineering Internal Rate of Return
GPS	Global Positioning System
HH	House Hold
IEE	Initial Environment Examination
IRC	Indian Road Congress
MRE	Mountain Risk Engineering
NFRP	Nepal Feeder Road Project
NRS	Nepal Road Standard
NTFP	Non Timber Forest Product
PHC	Public Health Clinic
PMEU	Planning, Monitoring and Evaluation Unit
TOR	Terms of Reference
VAT	Value Added Tax
VDC	Village Development Committee
VOC	Vehicle Operating Cost

SALIENT FEATURES OF THE PROJECT

Name of project: "Detail Engineering Survey, Details Design of Roads and Report Preparation of Khadketari Panchase Dobilla Sadak, Syangja".

Location:

Geographic Location: SyangjaDistrict, GandakiZone
Western Development Region, Nepal

GPS Co-ordinates of Major Obligatory Points:

S.N	Obligatory Points	Latitude(N)	Longitude€	Remarks
1	Khatke Tari	3117380.025	782542.252	
2	Parikabari	3117854.776	781296.507	
3	Lolasari	3117726.773	780512.491	
4	BhatKhola	3118162.111	779170.64	
5	BageKot	3118974.236	778378.84	
6	Jugle	3119459.68	777830.389	
7	Dadagau	3119470.769	777669.07	
8	Bagephadke	3120366.549	777482.269	
9	Siranchaur	3121561.855	776134.733	
10	Khadkeri	3121377.352	775684.906	
11	Bansin Deurali	3121102.708	774842.678	
12	Narikot	3121931.272	774052.359	
13	Kathi	3122855.03	774100.202	
14	Rahe	3123108.206	773955.158	
15	Naukhola	3123087.559	773457.048	
16	Kahule	3123554.165	772850.673	
17	Thadswara	3123254.949	771571.223	
18	DadaKharka	3124013.903	770377.008	
19	Karbare	3124355.753	769967.148	
20	Gahate	3124364.448	769512.622	
21	Pipaltari	3125167.414	768503.633	
22	Dobilla	3125835.187	766439.451	

Starting Point: Khadketari, Syangja District
Latitude :27°30'56.13"N
Longitude : 83°36'4.11"E
Elevation : 98.498 AMSL

End Point: Dobilla,Syangja District
Latitude : 27°27'42.85"N
Longitude :83°13'31.82"E
Elevation : 81.529 m AMSL

Geographical Feature : HillyTerrain
Terrain : Hilly
Climate : Tropical climate
Geology : Boulder Mixed Soil
Hydrology :Seti Khola, Kaule Khola, Boski Khola,Nanid Khola, Tuni Khola,Okadi Khola, Jare Kholais major river crossing and other numerous kholsi
Meteorology : Average annual rainfall is 1500 ml.

Classification of Road:

Classification : Class IV
Surface : Blacktop
Suggested longitudinal grade: 1% to 10%

Connection with Road Network:

S.N.	Name of Road	Length (Km)
1	Siddhartha Highway	181
2	Bhupiserchan Marga	

Alignment Details: Khadketari,Bhandaridad,Warikapari gaun,Bangemaidan gaun,Siranchaur gaun,Bangsing gaun, Panchase,Daha gaun,Saradi gaun,Rahe basti,Aarthargaun,Dadakharka gaun, Dobilla etc.

Structures

S.N.	Structures	Remarks
1	Culverts	
1.1	Slab Culverts	No
	Span	-
	Number	-
1.2	Pipe Culverts	Yes
	Diameter	900 mm
	Number	95
2	Causeways	Yes
	Span	Span 10m (Proposed)
	Number	2
	Span	Span 15m (Proposed)
	Number	2
	Span	Span 12m (Proposed)
	Number	1
	Span	Span 20m (Proposed)
	Number	1
3	Bridges	Yes
	Span	Span 30 m (Existing)
	Number	1
	Span	Span 25 m (Proposed)
	Number	1
4	Retaining Structures	Yes
4.1	Masonry Retaining Wall	Yes
4.2	Masonry Breast Wall	Yes
4.3	Gabion Retaining Wall	Yes
4.4	Gabion Breast Wall	Yes
5	Safety Barriers	Yes

Design Parameters:

S.N.	Design Parameters	Adopted Value (As per NRS 2070)
1	Design Speed	40 km/hr
2	Right of Way both side from road centre line	15 m
3	Formation width	8.5 m (without Drain)
4	Carriageway width	7m (5.5 m Black top)
5	Shoulder width	0.75 m (Both Side)
6	Camber of Carriageway % Service Road	2.5%
7	Camber of Shoulder	4%
8	Minimum radius in horizontal curve	15 m (12.5m exceptional)
9	Minimum radius in vertical curve	0 m
10	Minimum length	40 m
11	Maximum gradient	10%
12	exceptional gradient	12 or 11.5 m
13	Average gradient	7%
14	Minimum over taking distance	165m
15	Minimum Stopping Sight Distance	50 m
16	Maximum Super Elevation (%)	10 %

Cross-Section:

1.	Right of Way:	30m (15 m on either side of theroad)
2.	Formation Width	: 8.5 m (without Drain)
3.	Carriage Way Width	: 7m (5.5 m Black top)
4.	Shoulder Width	: 0.75 m (Both Side)
5.	Side Drain	: Semi-Trapezoidal Shape
6.	Camber	: 2.5%

Pavement:

Sub-Base	(1) Materials: Gravel Coarse (2) Thickness: 200mm
Base	(1) Materials: Crushed Stone (2) Thickness: 200mm
Surface	Type: DBSD

Summary of Cost

Summary of Cost

SN	Description of Works	Amount	Remarks
1	General Item	14,858,024.81	
2	Road Way Excavation	151,772,505.72	
3	Drain and Cross Drainage Work	236,853,299.66	
4	Structural works	83,528,973.17	
5	Pavement work	564,167,403.37	
6	Bio-Engineering	2,566,228.36	
7	Road Furnitures	26,617,047.17	
	Total	**1,080,363,482.26**	
	5%Contingency	**54,018,174.11**	
	5% Price adjustment Contingency	**54,018,174.11**	
	5% Physical Contingency	**54,018,174.11**	
	13 % VAT	**140,447,252.69**	
	Grand Total	**1,382,865,257.28**	
	Cost Per Km	**42,315,338.35**	

Total Project Cost: (Without Bridge and Property Acquisition Cost)
Total Project is **Rs. 1,382,865,257.28**

(One arab Thirty Eight crores Twenty Eight lakhs Sixty Fivethousand Two hundred Fifty Seven Rupees and Twenty Eight paisa only)

S.N.	Particulars	Studied Alignment
1	Total Cost	Rs.**1,382,865,257.28**
2	Rate per km	Rs.**42,315,338.35**
3	Length of Road	**32.680 Km**

Conclusion:
The road is highly demanded by the population of the influence area and this road is feasible in terms of topographical, geological, engineering, socio-economic, environmental and economic analysis and should go for further upgradation as soon as possible.

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Annex I : Topographic, Google, SRN and District Maps
Annex II : Photographs of Road Inventory Survey, DCP Test & Detailed Engg. Survey
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- BM and Station Data
- DCP Test Results
- Construction Material Quarry Site and Laboratory Test Result

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CHAPTER 1: GENERAL

1.1 Introduction

Transportation is one of the important infrastructures for overall development of the nation and its economy. Construction of new road and implementation of scientific transport network plays a vital for it. Variation in the demographic trend, productivity and other socio-economic factors of different location prioritize the development of new road alignment, upgradation and well organized transport network. Considering these facts, study of various new road alignments and upgradation are being done.

This report has been prepared as per the contract between Planning Monitoring and Evaluation Unit, Department of Roads as the Client and the GOEC NEPAL PVT. LTD,Buddhanagar, Kathmandu, Nepal, as the Consultant, as preparation of project report of "Detail Engineering Survey, Details Design of Roads and Report Preparation of Khadketari Panchase Dobilla Sadak, Syangja."This report is submitted as Draft report in accordance with the given Terms of Reference (TOR).

The proposed road connects different places of Syangjadistrict. The road starts from Khadketari of Siddhartha Highway(Chainage Km: 0+000) ofSyangja district and ends at Dobilla(Chainage Km: 32+680). This road will play a very important role in up-liftment of socio-economic condition of Syangja district & whole nation.It play vital role in agricultural development of an area.The proposed road will link other roads of national importance as well. Therefore, proper implementation of this road alignment will be very much beneficial in long term.

1.2 Location

The proposed road alignment lies in Syangja district, Gandaki zone of Western Development Region. The studied alignment starts from Khadketari of Siddhartha Highway, Syangja District(Chainage: 0+000),ofSyangja District and ends at Dobilla, Syangja District(Chainage: 32+680),. The alignment passes through many urban areas, settlement areas, cultivated land, and forest area and crosses many major and minor river crossings, plain terrain, of Syangjadistrict.

Figure: Map of Nepal Demarcating Studied District

1.3 Significance

The proposed road alignment joins Khadketari which ultimately connects to Dobilla of Syangja District.So, this road alignment has got very important significance in terms of national economy and development of the country.
The main objectives of the study are:

- To investigate alignments in terms of socio-economic factors, topography, geology, environmental aspects, other related factors, etc.
- To perform alignment detailed survey and design.
- To perform socio-economic and traffic study.
- To suggest option of upgrading and design accordingly.
- To develop environmental mitigation plan to reduce environmental impacts due to the road activities.
- To prepare detailed project report of the stated road based on sound techno-economical approach.

1.4 Connection with road network

The road connects Khadketari Municipality of Syangja and Dobilla VDC of Syangja District.The road alignment starts from Walling of Siddhartha Highway and connect to end point of Syangja District known as Walling.Syangja has great potential for agricultural production, country main Border as well as Industrial area. Therefore, proper implementation

of this road alignment will be very much beneficial for socio-economic development of Nepal.

Connection with Road Network:

S.N.	Name of Road	Length (Km)
1	Siddhartha Highway	181
2	Bhupiserchan Marga	

1.5 Map Study

Relevant maps and documents were collected for studying and analyzing the road alignment during the desk study and field visit. Following maps and documents were taken as main reference for the study:

Topographical Map

Land Use Map

Political Map

Geological Map

District Map

Zonal Map

Regional Map

Influence Area Map

Road Network Map

Nepal Road Statistics, 2004

District Profile, 2013

Previous Study Reports

The map study was carried out to get clear information of the proposed road alignment before and after field visit. Hence, the proposed road alignment was plotted on topographical map.

CHAPTER 2: SOCIO-ECONOMIC PROFILE

2.1 Influence Area

The influence area is the area which is directly or indirectly affected during or after road construction. Identification of influence area is the premier step for feasibility study of road. The influence area of the project area is demarcated in the map of the project area. The influence area is determined according to the topography of the villages, and nearest access to the existing road and probable foot trails which could be emerged to the proposed road. The road has direct influence on the area along the alignment and its surroundings. It will have significant influence on national economy as well. After the completion of this road, the social, cultural and economical pattern of Syangjadistrict which lies in Gandakizone of Western Development Region will be drastically changed.

During this study, the influence area is determined in relation to the provision of basic social services and is taken as the area contained within the premises that can be reached from the proposed road in a given period of time by non-motorized transport. The proposed road project will be very much beneficial for transportation of goods and passengers in short time period. It will linkSiddhartha Highway Road to other roads of national importance as well. It will link different VDCs and Municipality of SyangjaDistict.

Municipality/VDCs within the road alignment are depicted as in the table given below:
[Source: District Profile 2013]

Figure Municipality & VDC within Studied Area

Table: Municipality/VDCs within the Road Alignment

S.N	Influenced Area	HH	Total	Male	Female
1	Phedikhola VDC	3254	12341	5259	7082
2	Aandhikhola VDC	4125	16589	7072	9517
3	Kushma Municipality	10311	38600	17739	21861

2.2 Socio-economic data of the influenced area

Transportation is one of the important infrastructures for the development of the country. It plays vital role for the betterment of socio-economy aspect of the studied area along road alignment. Different aspects of modern society such as Population, Land Use Pattern, Utility Services (Electricity, Irrigation, Water supply, etc), Economic Activity (Agriculture, Industries, Employment, Business, Import and Export, Market, etc), Health and Education Sector, Communication Network and Administrative Facilities are directly influenced with the development of road network and transportation facilities. These aspects are linked with prosperity of human life style and overall development of the nation. Therefore, these aspects of the studied area are briefly described in different section below:

2.2.1 Population

Syangja District:

[Source: District Profile 2015].

A. Population Statistics:

Table: Population Statistics Syangja District

Zone	Gandaki
District Headquarter	Putalibazzar, Syangja
Area in sq.km	1,164 km²
Total Households	68,881
Total Population	289,148
Male	125,833
Female	163,315
Sex Ratio	0.77
Average HH Size	4.19

(3) Nature of Migration:

The main occupation of the VDC area is agriculture. Government officials from different places migrate here after their posting over this region. Most people from this region have tendency to migrate to other places from here for search of employment, business, and education and better life styles. Young people are also found migrated to urban areas and foreign countries for earning and higher education. People migrate to major cities like District headquarters of Syangja district namely as Putalibazzar, Walling, Butwal, Bhairahwa, Pokhara, Kathmandu.

2.2.2 Land Use Pattern

The project area falls under Temperate and cold zone. The climate, soil type, geographical and geological distribution, availability of different facilities and services are the main governing factors for the change in land use pattern. Land along the road alignment falls under settlement zone, cultivated area, forest area, river crossings and open field. Land use pattern of this road section is briefly summarized below:

Table: Land Use Pattern

Name of VDC/Municipality	Chainage		Remarks
	From	To	
Karamdi	0+000	5+650	Settlement & Cultivated Area
Kastan Dada	5+650	11+500	Forest
Dadagaun-Bage	11+500	15+200	Settlement & Cultivated Area
Siranchor	15+200	18+100	Cultivated Area
arikot-Daha-KOthi	18+100	23+700	Settlement & Cultivated Area
Rahe	23+700	25+000	Cultivated Area
Kaule	25+000	26+500	Settlement & Cultivated Area
Karbare	26+500	27+500	Barren Land
Karbare	27+500	29+600	Settlement & Cultivated Area
Pipaltari-Dobilla	29+600	32+680	Settlement & Cultivated Area

(1) Wildlife Sanctuary:

Forest area is the natural habitat for different type of wild animals, birds, flora and fauna. Along this road alignment and whole district, no such wildlife sanctuary, National Parks, wildlife reserves and hunting reserves are found. But in the forest area, different type of wild animals such as leopard, bear, monkey, deer, etc, different types of birds and medicinal herbs are found. Therefore, forest area should be preserved for preventing extinction of wild animals, birds and other valuable flora and fauna.

(2) Forestry:

Major timber of the district are Sal, Khayar, Satisal, Jamun, Karma, Sankhu, Teak, Bombax, Marmelos, Tooni, RajaBrikshya, Botadhyaro, Sirish, Kadam, Saaj, Fadiyor, Asna, Sisaun, Chanp, and Sahadavan. Non-timber forest products in the district include Harro, Barro, Bijayasal, Khajurpatta, Naagbeli, Sarpagandha, Tejpaat, Eucalyptus, Gumba, Variyara, and Bojho.

(3) Agricultural Production:

Table: Area, Production and Yield of Cereal Crops of Syangja

Year	Paddy			Maize			Millet			Wheat			Barley			Buckwheat		
	Area	Prod	Yield	Area	Prod	Yield	Area	Prod	Yield	Area	Prod	Yield	Area	Prod	Yield	Area	Prod	Yield
2010/11	19455	58240	2994	30900	97028	3140	16805	19325	1150	6500	13200	2031	200	120	600	205	113	550
2011/12	17000	58130	3419	26500	92750	3500	16805	19325	1150	5800	12150	2095	9	8	889	205	130	634

[Area in Hectare, Production in Metric Ton and Yield in Kg per Hectare]

Table: Area, Production and Yield of Cash Crops of Syangja

Year	Oilseed			Potato			Tobacoo			sugarcane		
	Area	Prod	Yield	Area	Prod	Yield	Area	Prod	Yield	Area	Prod	Yield
2010/11	266	197	741	810	12547	15490	0	0	0	18	270	15000
2011/12	266	197	741	850	10288	12104	0	0	0	20	405	202500

[Area in Hectare, Production in Metric Ton and Yield in Kg per Hectare]

Table: Livestock Population of Syangja

Year	Cattle	Buffaloes	Sheep	Goat	Pigs	Fowl	Duck
2010/11	92479	143895	6559	177642	11485	204152	4476
2011/12	91677	144460	7930	179085	12327	214667	6705

Table: Milk Animals and Milk Production in Syangja

Year	Milk Cow (Nos.)	Millk Buffalo (Nos)	Cow Milk	Buffalo Milk	Total Milk
2010/11	12742	62225	6693	48412	55105
2011/12	13631	62469	7160	48917	56077

Table: Net Meat Production in Syangja

Year	Buff Meat	Sheep Meat	Goat Meat	Pig Meat	Chicken	Duck Meat	Total Meat
2010/11	2908	29	745	108	182	0	3972
2011/12	2939	33	751	116	191	0	4030

Table: Egg Production in Syangja

Year	Laying Hen (Nos)	laying Duck (Nos)	Hen Egg	Duck Egg	Total Milk
2010/11	121617	685	11067	40	11107
2011/12	127344	680	11588	42	11630

(4) Settlement Pattern:

Population density of the district is 248.40/ha (2.84/km^2). The population density along the existing road and trail is high in comparison with other area. Main market area of the proposed road is Bhedi khola, Putalibazzar (Syangja). Population concentration in those areas is high due to the business as well as employment opportunity. A major portion of settlement land was observed in different VDCs and there are rare evidences of scattered houses. Houses are built with brick masonry and dry stone masonry using timber. The materials, used for roofing is slab, tin, etc.

2.2.3 Utility Services

(1)Electricity:

There isgood facility of electricity inSyangja district. The Kaligandaki "A" Hydroelectric Power Station built on the Kali Gandaki River is the largest hydroelectric project in Nepal, with an installed capacity of 144 MW. Besides the Kaligandaki "A", Aadhikhola hydroelectric and some other, smaller, hydroelectric projects have been started in this district.

Of all the districts in Nepal, Syangja is one of the few districts in the country that doesn't suffer from the problem of load shedding, or scheduled electric outages while the nation suffers hours of load shedding each day.

(3) Water Supply:

Water Coverage Supply (%)	78.51
Sanitation Coverage (%	68.4

2.2.4 Economic Activity

(1) Local Produces and the Resources:

In small and medium size land holding family, the crops are raised for the consumption by the family. In the project area no market, oriented agricultures is found. However, the surplus crops are sold either in local market or in the food deficit area of the hills. The main local products are Ghee, Orange, Nibuwa, Vogate, rice, Maize etc. The products of Bamboo and cash crops are the other resources in the project area.

(2) Export and Import:

Major export from the area is wheat, maize, oilseeds and fruits and vegetablesetc.exported to nearby District as well as throughout the country. Export and import in the project area can be summarized in the table.

Table: Export and Import

Export	Import
Rice , Wheat, maize, mustard, tomatoes etc	Electronic goods
Medicinal Herbs	Machines and machinery tools
Mango, Oranges and Banana etc.	Cooking Utensils
	Cloths

(4) Market and Fair:

Major market of this road section is Phedi Khola, Putalibazzar (Syangja). The major enterprise of Syangja district isrelated to agricultures, Market hub and Fruits.

(5) Tourism Potential:

Syangja Torism was established in 2005. With a view that Syangja is historically, culturally, religiously and naturally significant it will be counted one of the enchanting places of tourist destination in global level. It has been and will be working in the exploration of such potential beauty of the distric. Syangja bears the potentiality of rural and sport toursim, myterious and miraculous caves organic farming, trekking routes rafting, rock climbing bungee jumping and so on. The organization is determined to uplift the tourism developmentco-ordinating district level's organizations and government bodies working various tourism related activies. We are sure that the economic level of the people can be increased, social and educational field can be developed and cultural uniqeness can be protected and enriched through the development of tourism. Syangja tourism is the name of those collective and energetic youth people who really believe that tourism is for the entire upliftment. Alamdevi, Jagatradevi, Kaligandaki Rafting, Setibeni Dham, Ramdi, Bungi Jump, Paragliding, Boating, Labarkot are the major tourism and religious places of Syangja District.

2.2.5 Health

Health service is one of the basic infrastructures for the development of the country. It is basic requirement for human well-being as well. The Hospital, Health centre, Health post, sub Health post, PHC outreach clinic, Ayurvedic Aushadhalaya, Ayurvedic H.C. etc are shown in the Table.
[Source: CBS 2011]

Table: Health Facility

Health Center Type	Numbers
Zonal Hospital	1
District Hospital	1
Primary Health Center	3
Health Post	12
Sub-Health Post	55
Birthing Center	18

2.2.6 Education

Education is another vital infrastructure for development of nation. Without educated people, development is not possible. Education status of the district and VDC are indicated by the number of educational institution and student enrolment. Theliteracy rate of Syangja district is 76.61%. The summary of the educational institutions of the district and VDC are tabulated below.
[Source: CBS VDC Profile]

Table: Education Facility

VDC/ Municipality and sex	Population aged 5 years & above	Population who are			Literacy not stated	Literacy rate
		Can read & write	Can read only	Can't read & write		
Total						
Both Sex	265,025	203,034	4,323	57,502	166	76.61
Male	113,340	97,531	1,827	13,937	45	86.05
Female	151,685	105,503	2,496	43,565	121	69.55

2.2.7 Transport and Communication Network

There are many road networks within these districts. Almost all the VDCs of these districts are connected with road network. The east-west Highway passes through Syangja Distict. There are facilities of landlines phones and mobile phones of Nepal Telecom (PSTN, GSM, and CDMA) and NCELL (GSM) for communication. CDMA sets are available in village areas. There are also facilities of postal, courier service, banks, co-operatives and other financial institutions in this road section through post office.

2.2.8 Administrative Facilities

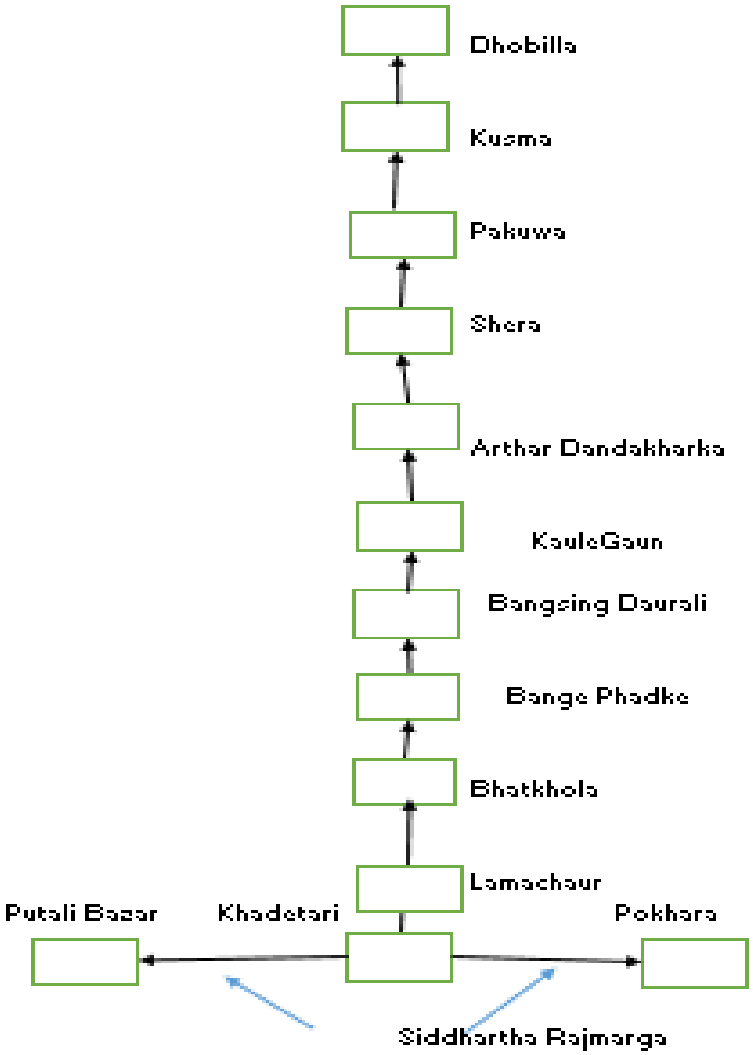
District level administrative office of Syangja district is located in district headquarters Putalibazzar, Syangja. Mainly they are District Administration Office, District Development Committee, District Police Office, District Post office, District Agriculture Office, District Education office, District Livestock Office, and District Soil Conservation and Watershed Management Office, and District Public Health Office, District Traffic Office,District Women Development Office, Nepal Telecom. In each VDC,there are VDC office,Temporary Police Post, Health Post,Drinking water and sanitary sub division,District technical office,District technical office,Agriculture and Forest Office and other administrative offices as well.

CHAPTER 3: TRAFFIC STUDIES AND PAVEMENT DESIGN

3.1 Traffic Data

Traffic data plays vital role for any transport project. The proposed road would connect the Walling Bazzar to Maidan. Walling Bazzar will be connected with the trade route by 2 Lane for better transportation network with Kalikakot VDC. The people from the Syangja and Parwat will be directly benefitted from this project. Further, the project road will connect different VDCs and Municipality of Syangja District.

Figure: Road Network in Project Area



The existing traffic flow and traffic growth rate can be taken as fundamental for the traffic forecast. To determine the present traffic volume manual count was conducted at different road section as mentioned below. Bus, Truck, Jeep, Tractor, Car, Bike, Pedestrian, Porter, etc are existing type of traffic on the route of the proposed alignment.

Table: Total number of Traffics

S.N.	Types of Vehicle		Nos. of Traffics
1.a	Truck	Multi-Axle	0
b		Heavy	9
c		Light	12
2.a	Bus	Big	0
b		light	15
c		Micro	17
3	Tractors	Tractors	25
4	Car	Car	11
5	Motorcycle	Motorcycle	55
6	Utility Vehicle	Utility Vehicle	16
7	Three Wheeler	Three Wheeler	0
8	Four Wheel Drive	Four Wheel Drive	18
9	Power Tiller	Power Tiller	0
10	Auto Rickshaw	Rickshaw	0
11	Non Motorized Cart	Bullock Cart	0
	Total		178

3.2 Existing Roads and Traffic flow

Presently, direct traffic flow from Waling, Syangja to Maidan occurs along the proposed road alignment. Existing road is servicing the traffic in the both season. The field team has recorded traffic volume directly at some nodal points. Further, traffic volume varies from season to season. When the consultant preceded the field survey, there is medium movement of vehicles and pedestrians due to relatively good road condition. The reliability of traffic count is checked with the interview of local people, some DoR & DDC officials.

S.N	**Influenced Area**	**HH**	**Total**	**Male**	**Female**
1	Phedikhola VDC	3254	12341	5259	7082
2	Aandhikhola VDC	4125	16589	7072	9517
3	Kushma Municipality	10311	38600	17739	21861

The Average Daily Traffic (ADT) obtained from the survey needs adjustment to determine Annual Average Daily Traffic (AADT). Seasonal factor for was assumed as 0.78 for this project based on the DoR study on the traffic volume and 7% growth rate.

Different consumable commodities like sugar, salt, clothes, oil, etc are imported to local village area and different agricultural products like barley, maize, wheat, pulses, cereals, etc are exported to big market. People in this region travel for different purposes such as official works, business purpose, employment, educational purpose, etc. After construction of the road, life of people here will be much easier than before.

3.3 Traffic Estimation

Normal Traffic

ADT estimated for 2016 is considered as normal traffic that is expected to grow over the service life at an estimated growth rate per annum. The following sections address the estimation of growth rate.

Traffic Estimation

Future traffic volume basically depends upon the two factors population growth rate and development in the agricultural as well as local productions. Population growth rate of the influence area is 0.78%.

Future Traffic

The normal practice in road construction is anticipating a future traffic with base to present traffic and arrive at the parameters and standard of the road. It should be noted that at least 10-20 years ahead planning should be done with present mode of data. For our purpose we have taken 15 years after the completion of the project that the anticipated traffic will play on it. Hence we assume that upto next 20 years the road will be sufficient for traffic volume. Three types of traffic that is normal, development and generated traffic and diverted traffic are to be considered for future traffic generation. The proposed roads traffic forecast will be high as the proposed road will links/connects the road at will links to major markets and service centre of the project area. The population growth rate of project district is 0.78% according to the census 2011 which is not sufficient enough for the traffic growth rate. So, the traffic growth rate in the project area is taken as 7% (r=0.07).

Traffic Growth Rate

Growth rate for the normal traffic is estimated based on the following:

Transport Sector Growth
Socio-Economic Parameters
Similar Project Findings

The mathematical model used for forecasting the growth rates from time series data is:
$\log P_N = N * \log (1+r) + \log P_0$

Where,
P_0/P_N = Number of Vehicles in base year / n^{th} year
N = Number of Years
r = annual growth rate of traffic

Transport Sector Growth
Transport sector in Nepal is dominated by road transport with limited contribution of rail /waterway based transportation and aviation sectors. In absence of time series statistics on motor vehicle registration, overall transport sector growth is considered to represent growth in road transport and demand thereof for the project road.

Socio-economic Parameters
Growth in relevant socio-economic parameters is also analyzed following the same principle for the period 1997-98 to 2013-14 time series data on constant price. Observed annual growth rates are:

Gross Domestic Product	5.48%
Real Per Capita Income	1.04%

Population in Nepal, as per 2011 Census has increased by 0.78% per annum. During past decades, the population and growth rate are as given below:

Table: Population and Annual Growth Rate

Year	Population (million)	Annual Growth Rate (%)
1991	1.01	
2001	1.14	2.55
2011	1.16	0.78

Growth Rate
Socio-economic Data
Major socio-economic parameters that influence traffic growth estimation are State income (GDP), population and per capita share. As, Nepal's economy is mainly dominated by the primary sector, growth in GDP is considered to be single most influencing indicator of the transport demand. Growth in population and per capita income have most influence on passenger travel demand, however, combined effect of population and per capita income growth nearly equates to the growth in GDP . Foreign aid disbursement per capita: USD 4.00

Population growth rate over last two decades varies between 2.55 to 0.78% per annum. During last decade, the change in population growth rate was 0.78%. The population of Syangja district is increasing yearly due to the migration. People migrate from Syangja district to foreign countries for employment and study purpose.

In view of the above analysis, discussions on economic parameters and conclusion on thereof, traffic growth rates can be established as:

For two/three Wheeler	7.0%
For Car	6.0%
For Passenger vehicles	8.0%
For Freight vehicles	7.0%

Adopted Growth Rate

The growth rates worked out from socio-economic parameters have been compared with that from Departmental Policy Document of Nepal to arrive at rational traffic projections. Adopted growth rate for various traffic is presented.

Table: Adopted Growth Rate

S. N.	Description	Vehicle Growth (%), per annum			
		2/3 Wheeler	Car	Bus	Truck
1	Socio-economic Data	7.0	6.0	8	7.5
2	Nepal Departmental Policy Document	7.5	6.5	6.0	6.0
Adopted Growth		**7.5**	**6.5**	**7.5**	**7.5**

Though the population growth rate of Syangja district is positive. There is high potential of industrial development so; people migrate from different places of country to Syangja district. Higher population growth would call for higher passenger movement demand than in average sector demand. On account of low per capita income, thrust of passenger demand shall be towards low cost option like bus and low cost vehicle option of two/three wheeler. Little higher freight transport demand is considered on account of increase in cross border movement. From the above table, vehicle growth rate can be taken as 7% for all vehicles.

Base year traffic flow

The base year traffic flow is estimated by Average Daily Traffic (ADT) currently using the Waling route, classified into the vehicle categories of truck, bus and tractor. The ADT is defined as the average number of traffic summed for both directions. Further ADT is multiplied by the seasonal factors 1.1 to convert it into Average Annual Daily Traffic (AADT). Base year traffic flow can be expressed by using a single number i.e. Passenger Car Unit.

Traffic Forecast in AADT in PCU for 20 Years

Table: Traffic Forecast for 20 Years

S.N.	Vehicle	Type	Manual 2017 Traffic Count (Both Direction)	Growth Rate 7% (Trend Analysis)	3 Yrs Constuction Period 2019 Traffic Forecast with 7% Growth Rate (A)	Divert from Other Roads (B)	Sum of Normal + Diverted Traffic (C=A+B)	Generated Traffic due to Road Improvement (1-20 Years) (D)	Total Traffic (E = C+D)	PCU (F)	ADT 2020 in PCU (G=E*F)	ADT in PCU for 20 Years Forcast 2040 (H)
1	Truck	Multi-Axle	0	0.07	0	0	0	0	0	4	0	0
2		Heavy	9	0.07	11	5	16	8	24	3	72	279
3		Light	12	0.07	15	9	24	12	36	1.5	54	209
4	Bus	Big	0	0.07	0	0	0	0	0	3	0	0
5		Mini	15	0.07	18	7	25	7	32	3	96	371
6		Micro	17	0.07	21	12	33	11	44	1.5	66	255
7	Tractors	Tractors	25	0.07	31	18	49	15	64	1.5	96	371
8	Car	Car	11	0.07	13	0	13	7	20	1	20	77
9	Motorcycle	Motorcycle	55	0.07	67	31	98	24	122	0.5	61	236
10	Utility Vehicle	Utility Vehicle	16	0.07	20	13	33	8	41	1	41	159
11	Three Wheeler	Three Wheeler	0	0.07	0	0	0	0	0	0.75	0	0
12	Four Wheel Drive	Four Wheel Drive	18	0.07	22	15	37	8	45	1	45	174
13	Power Tiller	Power Tiller	0	0.07	0	0	0	0	0	1.5	0	0
14	Auto Rickshaw	Rickshaw	0	0.07	0	0	0	0	0	1	0	0
15	Non Motorized Cart	Bullock Cart	0	0.07	0	0	0	0	0	6	0	0
	Total ADT in PCU for 20 Years											**2131**

Diverted and Generated Traffic

It is assumed that7% growth rate in normal traffic will accommodate for diverted and induced traffic, no any separate calculation is made for diverted and induced traffic.

As traffic forecast is made for 20 years after completion of road construction with 7% annual growth rate. As 7% growth rate in normal traffic will accommodate for diverted and induced traffic, no any separate calculation is made for diverted and induced traffic. AADT in PCU for 20 years forecast is calculated as 2131 which lies between range 2000-5000 so, studied road is classified as Feeder Road Class IV category.

3.4 Pavement Design

Pavement is most important component of highway section. An overall functioning of highway system greatly depends on the performance of its pavement. Furthermore, vehicle operating cost and entire highway economics and life cycle are interrelated to the pavement

design practise. The design procedure of flexible pavement involves the interplay of several variables such as the wheel loads, traffic, climate, terrain and sub-grade soil conditions. Depending upon specific regional or nationwide characteristics, most of the countries are practising some empirical and experience base methods for the design of flexible pavements. Therefore,pavement design is done by following three methods as per TOR.

1. **DoR Pavement Design Guideline Method (Flexible Pavement)**
2. **IRC Method for Flexible Pavement**
3. **TRL Overseas Road Note 31 Method**

3.4.1 DoR Pavement Design Guideline Method (Flexible Pavement)

General

Road pavement failure is mainly due to the traffic movement from both the magnitude of the individual wheel loads and the number of times these loads are applied. The total number of vehicles as well as wheel loads (axle load) should be considered for pavement design. The load imposed by passenger cars does not contribute significantly to the structural damage of the pavement. Therefore, cars and similar sized vehicles can be ignored for the structural design of pavement. Only the total number and the axle loading of the commercial vehicles (heavy vehicles) that will use the road during its design life need to be considered. In this context, heavy vehicles are defined as those having an unladen weight of 3000 kg or more. In some circumstances, particularly for low volume roads, construction traffic can be a significant component of overall traffic loading and the designs should take this into account. The total number of anticipated commercial vehicles during the design life is covered in to the cumulative equivalent standard axle of 8160 kg.

Design life

In the context pavement, design life does not mean that at the end of the period the pavement will be completely worn out and in need of reconstruction. It means that towards the end of the period the pavement will need to be strengthened so that it can continue to carry traffic satisfactorily for a further period. Condition surveys of bituminous pavements are used to determine not only the maintenance requirements but also the nature and rate of change of condition to help to identify if and when the pavement is likely to need strengthening. The design life for the pavement is considered as cumulative number of standard axles that can be carried before strengthening of pavement is necessary. It is recommended that National Highways should be designed for a life of 15 Years. Expressways and urban roads may be designed longer life for 20 Years. For other categories of roads, a design life of 10 to 15 years may be taken. For this studied road project, a design life of 15 years is taken after completion of construction.

Traffic Estimation

Base Year Traffic Flow

For the determination of the total traffic over the design life of the road, the first step is to estimate base year traffic flows. An estimate should be the Average Daily Traffic (ADT) currently using the route, classified into the vehicle categories of cars, light goods vehicles, trucks (heavy good vehicles) and buses. ADT is defined as number of traffic summed for both directions. Further ADT is multiplied by the seasonal factors to convert it into Average Annual Daily Traffic (AADT). Base year traffic flow can be expressed by using a single

number i.e. Passenger Car Unit. It is recommended that traffic count for the purpose of pavement design is conducted for 24 hours and 7 Days.

Traffic Forecasting

An extent of future traffic depends on many factors such as economic, land-use and demographic factors. Therefore, traffic forecasting is an uncertain process. In a developing economy the problem becomes more difficult because such economies are often very sensitive to the world prices of just one or two commodities. In order to forecast traffic growth it is necessary to separate traffic into the following three categories.

a) Normal Traffic

Traffic which will pass along the existing road or track even if no any new pavement is provided. The commonest method of forecasting normal traffic is to extrapolate time series data on traffic levels and assume that growth will either remain constant in absolute terms i.e. a fixed number of vehicles per year (a linear extrapolation), or constant in relative terms i.e. a fixed percentage increase.

b) Diverted Traffic

Traffic that changes from another route (or mode of transport) to the project road because of the improved pavement, but still travels between the same origin and destination. Where parallel routes exist, traffic will usually travel on the quickest route although this may not necessarily be the shortest. Thus, surfacing an existing road may divert traffic from a parallel and shorter route because higher speeds are possible on the surface road. Origin and destination surveys should be carried out to provpide data on the traffic diversions likely to arise. Diverted traffic is normally assumed to grow at the same rate as traffic on the road from it is diverted.

c) Generated Traffic

Additional traffic which occurs in response to the provision or improvement of the road. Generated traffic arises either because a journey becomes more attractive by virtue of a cost or time reduction or because of the increased developments that is brought about by the road investment. Generated traffic is difficult to forecast accurately and can be easily overestimated. It is only likely to be significant in those cases where the road investment brings about large reductions in transport costs. For example, in the case of a small improvement within an already developed highway system, generated traffic will be small and can normally be ignored. However, in the case of a new road allowing access to a undeveloped area, there could be large reductions in transport costs as a result of changing mode from, for example, animal based transport to motor vehicle transport. In such a case, generated traffic could be the main component of future traffic flow.

Note: As traffic forecast is made for 20 years after completion of road construction with 7% annual growth rate. As road is existing and only improvement is being done in this road project, it is assumed that 7% growth rate in normal traffic will accommodate for diverted and generated traffic so no any separate calculation is made for diverted and generated traffic.

Axle loading

An accurate estimate of the current traffic loading is essential for an appropriate pavement design. Traffic volumes can be determined by traffic counts, but for current vehicle loads can be found by an axle load survey. It is not rational to design pavement layer on the basis of legal axle load limits because of the widespread problem of overloading, In addition to this, the proportion of vehicles with partially loaded is unknown. In these circumstances of axle loading, pavement design across the world is accepted to design on the basis of Standard Axle i.e. 8.16 tonnes (80 KN). In Nepal, the legal axle load limit is 10.2 tonnes. Axle load surveys have been carried out as per procedure described in the TRL Overseas Road Note 31 for calculation of traffic load for pavement design in terms of cumulative equivalent standard axle loads. The data collected from these surveys are used to calculate the mean number of equivalent standard axles for a typical vehicle in each class. These values are then used in conjunction with traffic forecasts to determine the predicted cumulative equivalent standard axles that the road will carry over its design life.

Equivalence factor

The damage that vehicles do to a road pavement depends very strongly on the axle loads of the vehicles. For pavement design purposes the damaging power of axles is related to a 'standard' axle of 8.16 tonnes (80 kN) using equivalence factors which have been derived from empirical studies. In order to determine the cumulative axle load damage that a pavement will sustain during its design life, it is necessary to express the total number of heavy vehicles that will use the road over this period in terms of the cumulative number of equivalent standard axles (esa). Axle load surveys must be carried out to determine the axle load distribution of a sample of the heavy vehicles using the road. Data collected from these surveys are used to calculate the mean number of equivalent standard axles for a typical vehicle in each class. These values are then used in conjunction with traffic forecasts to determine the predicted cumulative equivalent standard axles that the road will carry over its design life. Equivalence factor is calculated by using the following relationships:

- Front steering wheel (single wheel) axle $EF = \left(\frac{Axle\ load, kgf}{5410\ kgf\ (53kN)} \right)^4$
- Single axle dual wheel $EF = \left(\frac{Axle\ load, kgf}{8160\ kgf\ (80kN)} \right)^4$
- Tandem axle dual wheel $EF = \left(\frac{Axle\ load, kgf}{14968\ kgf\ (146.8kN)} \right)^4$

Vehicle Damage Factor (VDF)

Where sufficient information on axle load is not available and project size does not warrant conducting an axle load survey, the indicative values of Vehicle damage factor (VDF) may be used as given in the table below. The Vehicle Damage factor (VDF) is the multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions. It is defined as equivalent number of standard axle per commercial vehicle. The VDF varies with the vehicle axle configuration, axle loading, and terrain type and from region to region. The VDF is arrived at axle load surveys on typical sections so as to cover various influencing factors, such as traffic mix, mode of transportation, commodities carried, time of the year, terrain, road conditions and degree of enforcement.

Table: Vehicle Damage Factor

S.N.	Vehicle Type	VDF
1	Heavy truck (three axle or more)	6.50
2	Heavy two axle	4.75
3	Mini truck/tractor	1.0
4	Large bus	0.50
5	Bus	0.35
6	Tractors	1.0

Distribution of commercial traffic over the carriageway

Total traffic AADT (both way) is distributed over the whole carriageway for design of pavement. During the calculation of design traffic (total equivalent standard axle) realistic study should be done for the directional distribution of total traffic. In the absence of adequate and conclusive data for particular project, it is recommended that following distribution may be assumed for design.

a) **Single lane roads: Traffic tends to be more channelized on single** lane roads than two-lane roads and to allow for this concentration of wheel load repetitions, the design should be based on total number of commercial vehicles in both direction.

b) **Two-lane single carriage roads/ Intermediate lane roads:** The design should be based on 75 percent of the total number of commercial vehicles in both directions.

c) **Four-lane single carriageway roads:** The design should be based on 40 percent of the total number of commercial vehicles in both directions.

d) **Dual carriageway roads:** The design of dual two lane carriageway roads should be based on 75 percent of the number of commercial vehicles in each direction. For dual three-lane carriageway and dual four lane carriageway, the distribution factor will be 60 percent and 45 percent respectively.

The traffic in each direction may be assumed to be half of the sum in both directions when the latter only is known. Where significant difference between the two streams can occur, condition in the more heavily trafficked lane should be considered for design.

Where, the distribution of traffic between the carriageway lanes and axle loads spectrum for the carriageway lanes are available, the design should be based on the traffic in the most heavily trafficked lane and the same design will normally be applied for the whole carriageway width.

Computation of Design Traffic

The design traffic is considered in terms of cumulative number of standard axles (in the particular lane carrying maximum traffic) to be carried during the design life of the pavement. This can be computed as:

$$N = \frac{365*[(1+r)^n - 1]}{r} * A * D * F$$

Where,

N = Cumulative number of standard axles to be catered for the design in terms of msa
A = Initial traffic in the year of completion of construction in terms of CVPD
D = Lane distribution factor
F = Vehicle damage factor (as shown above VDF table)
n = Design life in years = 15 years
r = annual growth rate of commercial vehicle (7%)

The traffic in the year of completion is estimated using the following formula:

$A = P*(1+r)^n$

Where,

A = Initial traffic in the year of completion of construction in terms of number CVPD
P = Number of commercial vehicles per day as per last count
r = Annual growth rate of commercial vehicle(7%)
n = No. of years between the last count and year of completion of construction (3 years)

Traffic volume count in 7 days:

Result of Classified Manual Vehicle Count

Start Date: 12/12/2017 Location: 2-

Road Link: Station:

Name of Road: Khadketari Panchase Dobila Sadak,Syangja Station No.:

Seasonal Variation Factor for the Month of Surveyed By:

Day 1 Date:12/12/2017

Date	Start Time (Hrs)	Volume of Vehicles																																
		Truck						Bus						Car		Motor Cycle		Utility Vehicle		Tractor		Three Wheeler		Rickshaw		Bullock Cart		Four Wheel Drive/Jeep,Van		Power Tiller		Total		
		Multi Axle		Heavy		Light		Big		Mini		Micro																						
		a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	
	6:00-7:00			0	0	1	0			0	1	1	0	1	0	2	3	1	0	0	1							1	1			7	6	13
	7:00-8:00			1	0	0	1			1	1	2	2	0	0	3	1	1	0	2	1							3	1			13	7	20
12.12.2017	8:00-9:00			0	0	0	1			0	1	1	1	1	0	2	4	0	1	1	0							1	1			6	9	15
	9:00-10:00			0	1	1	0			1	1	0	1	1	1	3	2	1	1	4	2							1	0			12	9	21
	10:00-11:00			1	0	1	0			1	0	0	0	0	1	1	3	0	0	1	0							1	1			6	5	11
	11:00-12:00			0	0	0	1			1	0	0	0	0	1	2	1	1	0	3	1							0	1			7	5	12
	12:00-1:00			0	0	1	0			0	0	0	1	1	1	2	2	0	1	3	2							1	0			8	7	15
	1:00-2:00			0	0	1	1			1	1	1	0	1	0	4	2	1	1	1	0							1	1			11	6	17
	2:00-3:00			0	1	0	1			0	0	1	0	0	0	4	2	0	0	1	0							0	1			6	5	11
	3:00-4:00			0	0	1	0			1	1	0	2	0	0	3	4	1	1	2	1							1	2			9	11	20
	5:00-6:00			1	0	1	1			1	0	1	1	1	0	3	2	0	1	3	1							1	1			12	7	19
Sub total for 12 hr.		0	0	3	2	7	6	0	0	7	6	7	8	6	4	29	26	6	6	21	9	0	0	0	0	0	0	11	10	0	0	97	77	174
Sub total (a+b)		0		5		13		0		13		15		10		55		12		30		0		0		0		21		0		174		

Day 2

Date	Start Time (Hrs)	Volume of Vehicles																																
		Truck						Bus						Car		Motor Cycle		Utility Vehicle		Tractor		Three Wheeler		Rickshaw		Bullock Cart		Four Wheel Drive/Jeep,Van		Power Tiller		Total		
		Multi Axle		Heavy		Light		Big		Mini		Micro																						
		a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	
	6:00-7:00			1	0	1	0			1	1	1	2	0	1	2	3	1	1	1	1							0	1			8	10	18
	7:00-8:00			0	1	0	1			1	1	2	1	1	1	3	2	0	1	3	2							2	0			12	10	22
	8:00-9:00			0	0	0	1			1	0	1	1	0	0	4	2	1	0	1	1							1	1			9	6	15
	9:00-10:00			1	1	1	0			0	1	1	1	1	0	3	2	1	1	2	1							1	0			11	7	18
	10:00-11:00			0	0	0	1			1	1	0	1	1	0	4	2	1	1	1	1							1	1			9	8	17
13.12.2017	11:00-12:00			1	0	1	0			0	1	1	0	0	0	3	1	0	1	0	2							1	1			7	6	13
	12:00-1:00			0	0	1	0			1	0	0	0	1	0	1	3	1	1	1	1							0	2			6	7	13
	1:00-2:00			0	1	1	1			0	1	1	1	0	1	4	3	1	1	2	0							1	0			10	9	19
	2:00-3:00			1	0	0	1			0	1	0	0	1	1	3	2	0	0	1	1							1	1			7	7	14
	3:00-4:00			0	0	1	0			1	1	2	2	1	0	4	3	1	1	1	1							0	1			11	9	20
	5:00-6:00			1	1	1	0			1	0	1	2	0	0	3	2	0	0	1	1							1	1			9	7	16
Sub total for 1 hr.		0	0	5	4	7	5	0	0	7	8	10	11	6	4	34	25	7	8	14	12	0	0	0	0	0	0	9	9	0	0	99	86	185
Sub total (a+b)		0		9		12		0		15		21		10		59		15		26		0		0		0		18		0		185		

Day 3

Date	Start Time (Hrs)	Volume of Vehicles																																	
		Truck						Bus						Car		Motor Cycle		Utility Vehicle		Tractor		Three Wheeler		Rickshaw		Bullock Cart		Four Wheel Drive/Jeep,Van		Power Tiller		Total		
		Multi Axle		Heavy		Light		Big		Mini		Micro																							
		a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	
	6:00-7:00			0	0	0	0			0	0	0	2	0	0	2	2	1	1	1	1							1	1			5	7	12	
	7:00-8:00			0	1	1	1			1	1	2	1	0	1	3	3	0	2	1	0							1	1			9	11	20	
14.12.2017	8:00-9:00			0	0	1	0			1	1	1	1	1	0	4	4	1	1	0	1							0	0			9	8	17	
	9:00-10:00			1	0	0	1			1	0	1	2	1	1	3	1	1	0	1	1							1	1			10	7	17	
	10:00-11:00			0	0	1	0			0	1	0	1	1	1	4	2	2	1	1	0							1	1			10	7	17	
	11:00-12:00			1	0	1	0			1	1	1	0	0	1	4	2	1	0	1	0							1	1			11	5	16	
	12:00-1:00			0	1	0	1			1	1	0	0	0	0	2	3	1	1	0	1							1	0			5	8	13	
	1:00-2:00			1	0	1	0			0	0	1	0	0	1	2	1	1	1	1	1							1	0			8	4	12	
	2:00-3:00			0	1	0	1			1	1	2	1	1	0	4	3	2	1	0	0							0	1			10	9	19	
	3:00-4:00			1	0	1	1			1	0	1	1	0	1	3	2	1	0	1	1							1	0			10	6	16	
	5:00-6:00			0	1	0	1			1	1	2	1	1	1	2	3	1	1	1	1							0	1			8	11	19	
Sub total for 1 hr.		0	0	4	4	6	6	0	0	8	7	11	10	5	7	33	26	12	9	8	7	0	0	0	0	0	0	8	7	0	0	95	83	178	
Sub total (a+b)		0		8		12		0		15		21		12		59		21		15		0		0		0		15		0		178			

Day 4

Date	Start Time (Hrs)	Volume of Vehicles																																
		Truck						Bus						Car		Motor Cycle		Utility Vehicle		Tractor		Three Wheeler		Rickshaw		Bullock Cart		Four Wheel Drive/Jeep,Van		Power Tiller		Total		
		Multi Axle		Heavy		Light		Big		Mini		Micro																						
		a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	
	6:00-7:00			1	0	1	0			1	0	2	2	1	1	2	3	0	1	1	1									1	1			10	9	19
	7:00-8:00			0	1	1	0			1	1	1	1	1	0	3	1	1	0	1	0									0	0			9	4	13
15.12.2017	8:00-9:00			0	0	0	1			1	1	1	1	0	1	4	2	0	1	1	1									1	1			8	9	17
	9:00-10:00			1	0	0	1			1	1	1	0	0	0	2	2	1	0	3	2									0	1			9	7	16
	10:00-11:00			1	1	1	0			0	0	0	1	0	0	1	2	0	1	1	1									1	2			5	8	13
	11:00-12:00			0	0	0	1			1	1	1	0	1	1	4	3	1	0	0	1									1	1			9	8	17
	12:00-1:00			0	1	0	1			1	1	0	0	1	0	1	2	1	1	1	1									1	2			6	9	15
	1:00-2:00			1	0	0	1			1	1	0	1	1	0	2	3	1	0	1	1									0	1			7	8	15
	2:00-3:00			0	1	1	0			0	0	1	0	0	1	2	2	0	1	0	1									1	0			5	6	11
	3:00-4:00			1	0	0	1			1	0	1	1	1	1	4	3	1	1	1	0									1	1			11	8	19
	5:00-6:00			0	1	1	1			0	1	1	2	0	0	2	2	1	1	1	1									1	2			7	11	18
Sub total for 1 hr.		0	0	5	5	5	7	0	0	8	7	9	9	6	5	27	25	7	7	11	10	0	0	0	0	0	0	8	12	0	0	86	87	173
Sub total (a+b)		0		10		12		0		15		18		11		52		14		21		0		0		0		20		0		173		

Day 5

Date	Start Time (Hrs)	Volume of Vehicles																																
		Truck						Bus						Car		Motor Cycle		Utility Vehicle		Tractor		Three Wheeler		Rickshaw		Bullock Cart		Four Wheel Drive/Jeep,Van		Power Tiller		Total		
		Multi Axle		Heavy		Light		Big		Mini		Micro																						
		a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	
	6:00-7:00			0	1	0	0			1	1	1	2	1	1	4	1	0	0	1	1							1	1			9	8	17
	7:00-8:00			1	0	1	1			1	1	1	1	1	0	2	2	1	0	1	1							2	2			11	8	19
16.12.2017	8:00-9:00			0	1	0	1			1	1	1	1	0	1	2	2	1	1	1	0							1	1			7	9	16
	9:00-10:00			1	1	1	0			1	0	0	1	0	1	4	3	0	11	4	2							1	0			12	19	31
	10:00-11:00			0	0	0	1			0	1	1	1	1	0	3	2	0	1	1	0							1	1			7	7	14
	11:00-12:00			1	0	1	0			1	1	0	0	1	0	2	2	0	0	3	1							2	1			11	5	16
	12:00-1:00			1	1	1	0			1	0	1	0	0	1	4	2	1	1	1	1							1	0			11	6	17
	1:00-2:00			0	0	1	0			0	1	0	0	0	0	2	2	0	0	3	0							0	1			6	4	10
	2:00-3:00			1	1	1	1			1	0	1	0	0	1	3	3	1	0	1	2							1	2			10	10	20
	3:00-4:00			0	0	0	1			1	1	0	1	1	0	4	3	1	0	3	1							1	1			11	8	19
	5:00-6:00			1	0	1	1			1	1	1	2	1	1	2	2	0	1	1	1							1	1			9	10	19
Sub total for 1 hr.		0	0	6	5	7	6	0	0	9	8	7	9	6	6	32	24	5	15	20	10	0	0	0	0	0	0	12	11	0	0	104	94	198
Sub total (a+b)		0		11		13		0		17		16		12		56		20		30		0		0		0		23		0		198		

Day 6

Date	Start Time (Hrs)	Volume of Vehicles																																	
		Truck						Bus						Car		Motor Cycle		Utility Vehicle		Tractor		Three Wheeler		Rickshaw		Bullock Cart		Four Wheel Drive/Jeep,Van		Power Tiller		Total		
		Multi Axle		Heavy		Light		Big		Mini		Micro																							
		a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	
	6:00-7:00			0	0	0	1			1	1	2	1	0	1	2	2	1	1	1	1							1	1			8	9	17
	7:00-8:00			0	1	0	0			1	1	1	1	1	0	2	1	1	1	2	2							0	1			8	8	16
17.12.2017	8:00-9:00			1	0	1	0			1	1	0	0	0	1	3	3	0	1	1	0							1	0			8	6	14
	9:00-10:00			1	0	0	1			1	1	1	0	1	0	2	2	1	0	1	1							0	0			8	5	13
	10:00-11:00			0	1	1	0			0	1	0	1	1	1	2	1	0	1	3	2							1	1			8	9	17
	11:00-12:00			0	0	0	0			1	1	0	0	1	0	1	3	1	0	1	0							0	1			5	5	10
	12:00-1:00			0	1	1	1			1	0	1	0	0	1	3	2	1	1	2	1							1	1			10	8	18
	1:00-2:00			0	0	0	1			0	1	0	0	0	0	2	2	0	0	1	1							1	1			4	6	10
	2:00-3:00			1	0	1	0			1	0	1	1	0	1	3	3	1	1	3	1							1	0			12	7	19
	3:00-4:00			0	1	0	1			0	1	1	2	1	1	2	2	0	1	1	0							0	1			5	10	15
	5:00-6:00			1	0	1	0			1	1	0	1	1	0	2	3	1	1	1	1							1	1			9	8	17
Sub total for 1 hr.		0	0	4	4	5	5	0	0	8	9	7	7	6	6	24	24	7	8	17	10	0	0	0	0	0	0	7	8	0	0	85	81	166	
Sub total (a+b)		0		8		10		0		17		14		12		48		15		27		0		0		0		15		0		166			

Day 7

Date	Start Time (Hrs)	Volume of Vehicles																																
		Truck						Bus						Car		Motor Cycle		Utility Vehicle		Tractor		Three Wheeler		Rickshaw		Bullock Cart		Four Wheel Drive/Jeep,Van		Power Tiller		Total		
		Multi Axle		Heavy		Light		Big		Mini		Micro																						
		a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	
	6:00-7:00			0	0	0	1			1	0	0	0	1	0	2	3	0	1	1	1							1	0			6	6	12
	7:00-8:00			1	1	0	1			1	1	1	1	1	1	3	2	1	0	3	1							1	1			12	9	21
18.12.2017	8:00-9:00			1	0	1	0			1	1	1	1	1	0	3	2	1	1	0	1							1	1			10	7	17
	9:00-10:00			0	1	1	0			1	1	0	1	0	1	3	2	1	1	1	1							1	1			8	9	17
	10:00-11:00			0	0	1	0			0	1	1	0	0	1	2	2	1	0	1	1							1	1			7	6	13
	11:00-12:00			1	0	0	1			1	0	0	0	0	0	3	2	1	1	1	0							1	0			8	4	12
	12:00-1:00			0	1	1	0			0	1	1	0	1	1	3	2	1	0	2	1							1	1			10	7	17
	1:00-2:00			1	1	0	1			0	0	0	1	0	1	2	2	0	1	1	1							1	1			5	9	14
	2:00-3:00			0	0	0	0			1	0	1	1	1	0	3	3	1	1	1	1							0	0			8	6	14
	3:00-4:00			1	1	1	0			0	1	1	1	0	1	2	2	0	1	3	1							1	0			9	8	17
	5:00-6:00			0	0	0	1			1	1	1	2	0	0	2	4	1	1	1	1							0	1			6	11	17
Sub total for 1 hr.		0	0	5	5	5	5	0	0	7	7	7	8	5	6	28	26	8	8	15	10	0	0	0	0	0	0	9	7	0	0	89	82	171
Sub total (a+b)		0		10		10		0		14		15		11		54		16		25		0		0		0		16		0		171		

Detail Design Calculation as per DoR Pavement Design Guideline Method (Flexible Pavement)

Table: Calculation of Cummulative Number of Standard Axles by DoR Method.

S.N.	Vehicle	Type	2017 Traffic Count (Both Direction)	Growth Rate 7% (Trend Analysis)	2020 Traffic Forecast with 7% Growth Rate	Divert from Other Roads	Sum of Normal + Diverted Traffic	Generated Traffic due to Road Improvement (for 15 Years) (Assumed)	Total ADT	AADT 2020 (A) with seasonal factor 0.91	VDF (F)	Lane Distribution Factor (D)	A*F*D	Cumulative Number of Standard Axles (N)	Remarks
1	Truck	Multi-Axle	0	0.07	0	0	0	0	0	0	6.5	0.75	0	0	
2		Heavy	9	0.07	11	5	16	8	24	22	4.75	0.75	78	715423	
3		Light	12	0.07	15	9	24	12	36	33	1	0.75	25	229302	
4	Bus	Big	0	0.07	0	0	0	0	0	0	0.5	0.75	0	0	
5		Mini	15	0.07	18	7	25	7	32	29	0.35	0.75	8	73377	
6		Micro	17	0.07	21	12	33	11	44	40	0.35	0.75	11	100893	
7	Tractors	Tractors	25	0.07	31	18	49	15	64	58	1	0.75	44	403572	
	Total													1522567	
Cumulative Number of Standard Axles for design period (N)														**1522567**	**esa**
Cumulative Number of Standard Axles for design period (N)														**1.52**	**msa**

Cummulative Number of Standard Axles for design period is taken as **1.52 ≈2msa**which lies between 1 to 10 msa

Pavement design for this project according to DoR Pavement Design Guideline is Plate I – Recommended Design for Traffic 2 msa for CBR Value 9%& 10%. According to that plate I, the total pavement thickness is 350 mm with 20 mm Plan Concrete, Binder Course 50 DBM, Granular Base 150 mm and Granular Sub-base 150 mm.

Sub-Grade and DCP Values

The sub-grade in cut and fill should be well compacted to utilize its full strength and to economize on the overall thickness of the pavement required. The general requirements for the construction detail of sub-grade should be referred to the Section 1000 of Standard Specifications for Road and Bridge Works.

For design purposes it is important that the strength of the subgrade is not seriously underestimated for large areas of pavement or overestimated to such an extent that there is a risk of local failures.

The CBR value of the subgrade is obtained from the DCP Test carried throughout the length of the road in 500 m interval. The CBR values are shown in Annex. The Design CBR value for each Package has been determined as per the TRL Overseas Road Note 8 (60° Cone), the TRL Publication**.**

Table: CBR Value

Chainage	CBR in %
0+000	10
0+500	10
1+000	10
1+500	11
2+000	9
2+500	9
3+000	9
3+500	8
4+000	9
4+500	9
5+000	10
5+500	10
6+000	21
6+500	21
7+000	20
7+500	14
8+000	17
8+500	23
9+000	18
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31+500	9
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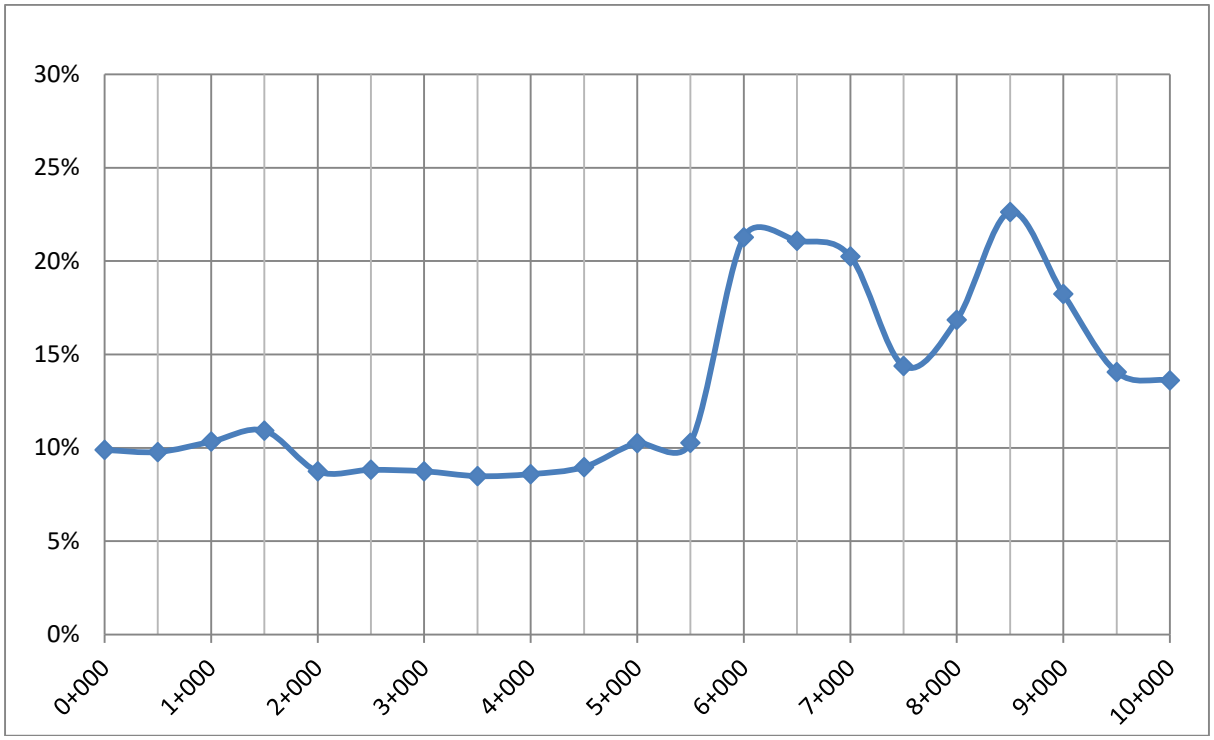
32+500	8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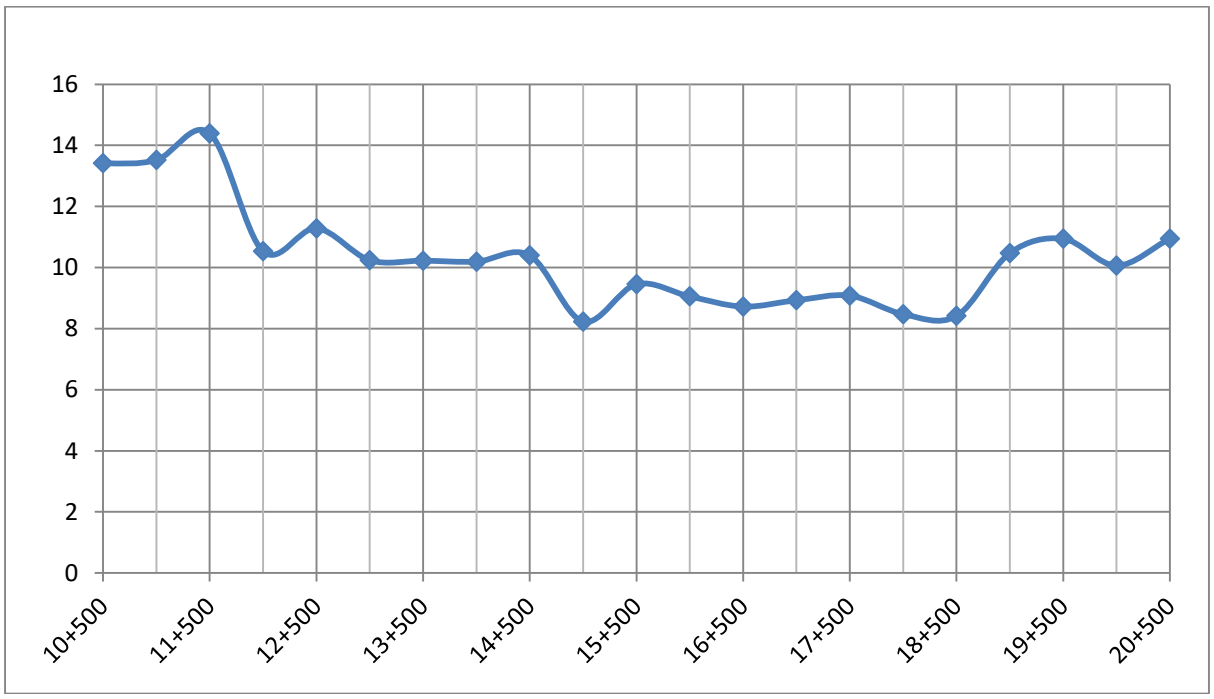
25%
20%
15%
10%
5%
0%
0+000
1+000
2+000
3+000
4+000
5+000
6+000
7+000
8+000
9+000
10+000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20+500

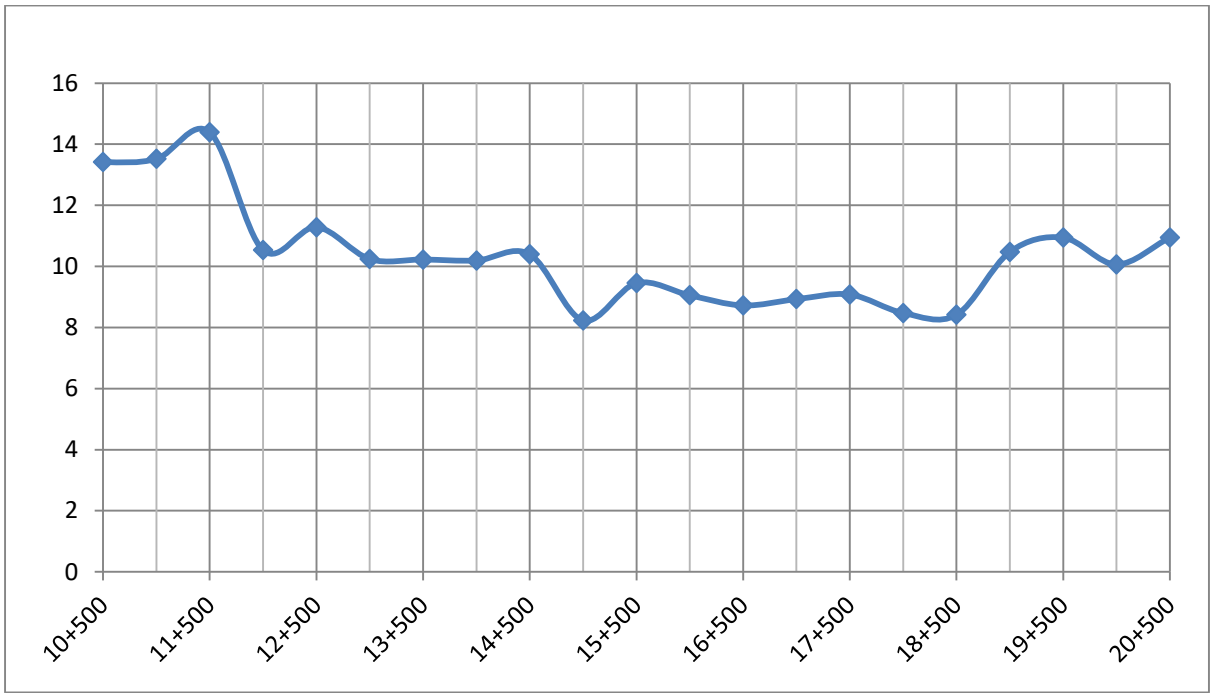


Figure : CBR Graphs

Annex-II: Pavement Design Chart

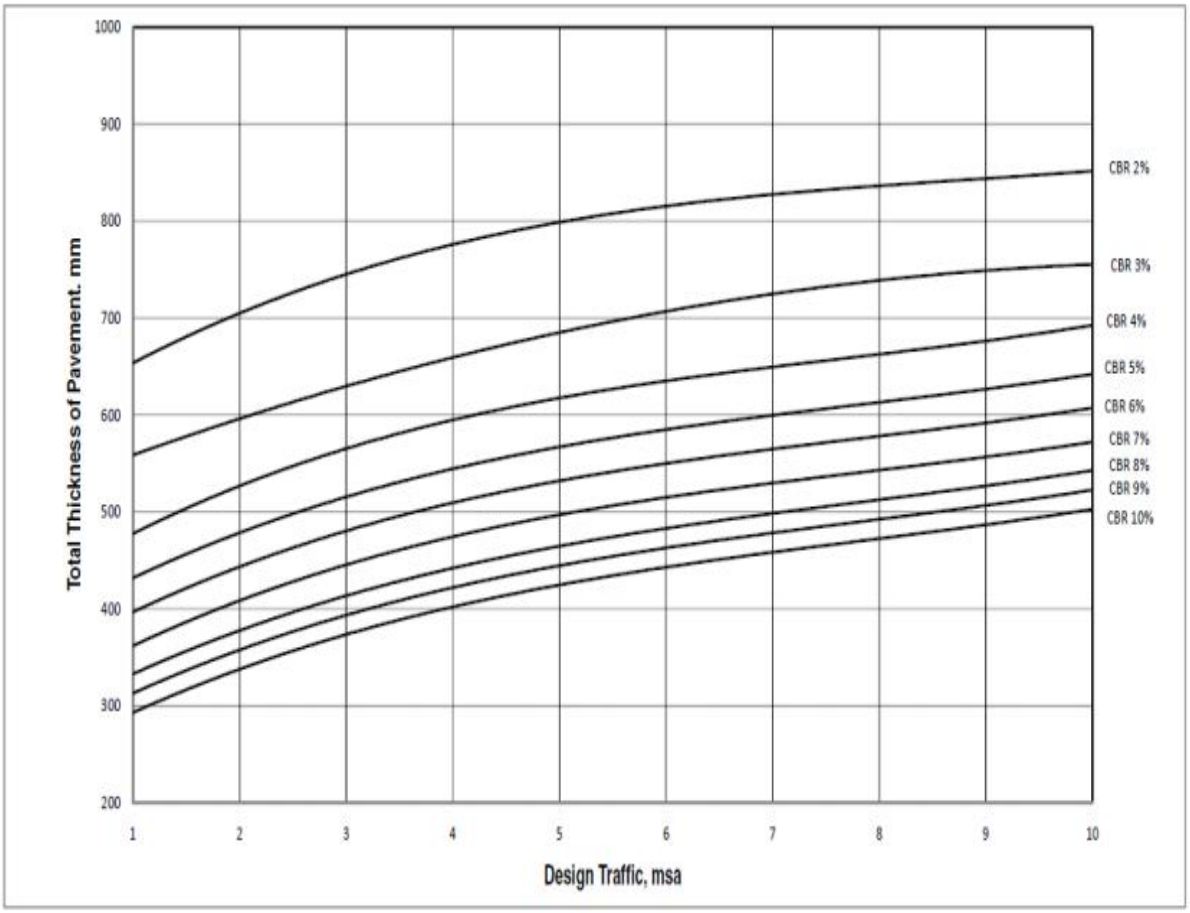


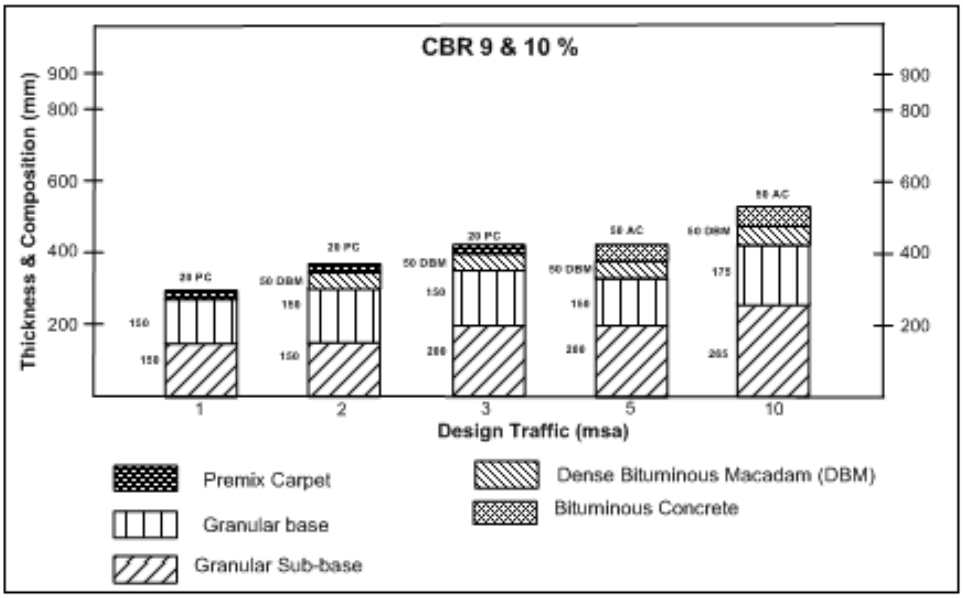
Figure 4 Pavement Thickness Design Chart 1-10 msa

Figure: Pavement Thickness and Composition

Pavement Design Catalogue

Plate I - Recommended Design for Traffic Range 1 - 10 msa

CBR 9 & 10%					
Cumulative Traffic, msa	Total Pavement Thickness, mm	Pavement Composition			
		Bituminous Surfacing		Granular Base, mm	Granular Sub-base, mm
		Wearing Course, mm	Binder Course, mm		
1	300	20 PC		150	150
2	350	20 PC	50 DBM	150	150
3	400	20 PC	50 DBM	150	200
5	450	50 AC	50 DBM	150	200
10	540	50 AC	50 DBM	175	265



Pavement Thickness and Composition

Pavement design for this project according to DoR Pavement Design Guideline is Plate I – Recommended Design for Traffic 2 msa for CBR Value 9%& 10%. According to that plate I, the total pavement thickness is 350 mm with 20 mm Plan Concrete, Binder Course 50 DBM, Granular Base 150 mm and Granular Sub-base 150 mm.

Sub-Base Coarse

Sub-base construction material requirements and construction procedure shall be followed the standard Specification for Road and Bridge Works (Clause 12001). From drainage consideration the granular sub-base should extended over the entire formation width. The thickness of the granular sub-base layer is 325 mm. In the areas affected by frost, care should be taken to avoid using frost susceptible materials in the sub-base.

Base Coarse

Unbound granular bases which comprise conventional Graded Crushed Stone and Water Bound Macadam (WBM) base shall be provided as per the Standard Specification (Clause

1202 and 1203). Materials used in the base must satisfy the grading and physical requirements in the Standard Specification. The thickness of granular base is 150 mm.

3.4. 2IRC Method for Design of Flexible Pavement

General

Indian Roads Congress (IRC) has specified the design procedures for flexible pavements based on CBR Value and cumulative number of standard axles to be catered for design in terms of million standard axle (msa). This guidelines follows analytical designs and developed set of designs upto 150msa in IRC: 2012

Design Procedure

1. Design is based on the performance of existing designs and using analytical approach, simple design charts and a catalogue of pavement designs added in the code.

2. The pavement designs are given for subgrade CBR values ranging from 1% to 15% and design traffic ranging from 1 msa to 150 msa,

3. Using the following simple input parameters, appropriate designs could be chosen for the given traffic and soil strength.
   - Design Traffic in terms of cumulative number of standard axles.
   - CBR value of subgrade

Design Traffic

The method considers traffic in terms of the cumulative number of standard axles (8160kg) to be carried by the pavement during the design life. This requires the following information:

- Initial traffic in terms of Commercial Vehicles per Day (CVPD)
- Traffic growth rate during the design life
- Design life in number of years
- Vehicle Damage Factor (VDF)
- Distribution of commercial traffic over the carriage way

Initial Traffic in terms of CVPD

Initial traffic is determined in terms of commercial vehicles per day (CVPD). For the structural design of the pavement only commercial vehicles are considered assuming ladel weight of three tone or more and their axle loading will be considered. Estimate of the initial daily average traffic flow for any road should normally be based on 7-day 24 hour classified traffic counts (ADT). In case of new roads, traffic estimates can be made on the basis of potential land use and traffic on existing routes in the area.

Design Life

For purpose of the pavement design, the design life is defined in terms of the cumulative number of standard axles that can be carried before strengthening of the pavement is necessary.It is recommended that pavements for arterial roads like National Highway should be designed for a life of 15 Years. Feeder roads and urban roads should be designed for 20 years and other categories of roads for 10 to 15 years.

Traffic Growth Rate

Traffic growth rates can be estimated by:

- By studying the past trends of traffic growth
- By establishing econometric models

If adequate data is not available, it is recommended that an average annual growth rate of 7% may be adopted.

Vehicle Damage Factor

The vehicle damage factor (VDF) is a multiplier for converting the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle-load repetitions. It is defined as equivalent number of standard axles per commercial vehicle. The axle load equivalency factors are used to convert different axle load repetitions into equivalent standard axle load repetitions. The axle load equivalency factors recommended in the AASHTO guide are given in table below. They are used for converting different axle load repetitions into equivalent standard axle load repetitions.

Table: Axle Load Equivalency Factors as recommended by AASHTO Guide

S.N.	Gross Axle Weight (Kg)	Load Equivalency Factors		Remarks
		Single Axle	Tandem Axle	
1	900	0.0002	0.0000	
2	1810	0.0020	0.0002	
3	2720	0.0090	0.0010	
4	3630	0.0310	0.0030	
5	4540	0.0800	0.0060	
6	5440	0.1760	0.0130	
7	6350	0.3500	0.0240	
8	7260	0.6100	0.0430	
9	8160	1.0000	0.07500	
10	9070	1.5500	0.1100	
11	9980	2.3000	0.1660	
12	10890	3.2700	0.2420	
13	11790	4.4800	0.3420	
14	12700	5.9800	0.4700	
15	13610	7.8000	0.6330	
16	14520	10.0000	0.8340	
17	15420	12.5000	1.0800	
18	16320	15.5000	1.3800	
19	17230	19.0000	1.7300	
20	18140	23.0000	2.1400	
21	19051	27.7000	2.6100	
22	19958	33.0000	3.1600	
23	20865	39.3000	3.7900	
24	21772	46.5000	4.4900	
25	22680	55.0000	5.2800	
26	23587	-	6.1700	
27	24494	-	7.1500	
28	25401	-	8.2000	
29	26308	-	9.4000	
30	27216	-	10.7000	

S.N.	Gross Axle Weight (Kg)	Load Equivalency Factors		Remarks
		Single Axle	Tandem Axle	
31	28123	-	12.1000	
32	29030	-	13.7000	
33	29937	-	15.4000	
34	30844	-	17.2000	
35	31752	-	19.2000	
36	32660	-	21.3000	
37	33566	-	23.6000	
38	34473	-	26.1000	
39	35380	-	28.8000	
40	36288	-	31.7000	

When sufficient information on axle loads is not available and the project size does not warrant conducting an axle load survey, the indicative values of vehicle damage factor as given in table below may be used.

Table: Vehicle Damage Factor According to Terrain

S.N.	Initial Traffic Volume in terms of CVPD	Terain		Remarks
		Rolling	Hilly	
1	0-150	1.5	0.5	
2	150-1500	3.5	1.5	
3	More than 1500	4.5	2.5	

Where sufficient information on axle load is not available and project size does not warrant conducting an axle load survey, the indicative values of Vehicle damage factor (VDF) may be used as given in the table below. The Vehicle Damage factor (VDF) is the multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions. It is defined as equivalent number of standard axle per commercial vehicle. The VDF varies with the vehicle axle configuration, axle loading, and terrain type and from region to region. The VDF is arrived at axle load surveys on typical sections so as to cover various influencing factors, such as traffic mix, mode of transportation, commodities carried, time of the year, terrain, road conditions and degree of enforcement.

Table: Vehicle Damage Factor

S.N.	Vehicle Type	VDF
1	Heavy truck (three axle or more)	6.50
2	Heavy two axle	4.75
3	Mini truck/tractor	1.0
4	Large bus	0.50
5	Bus	0.35
6	Tractors	1.0

In case the class mark of the axle load survey does not match with the above axle loads, 4th Power Law may be used for converting axle loads into equivalent standard axle loads using the following formula.

Single Axle Load
Equivalency Factor = (axle load in kg/8160)^4

Tandem Axle Load
Equivalency Factor = (axle load in kg/14968)^4

Vehicle Distribution
A realistic assessment of distribution of commercial traffic by direction and by lane is necessary as it directly affects the total equivalent standard axle load application used in the design. Until reliable data is available, the following distribution may be assumed.

a) **Single lane roads:** Traffic tends to be more channelized on single lane roads than two-lane roads and to allow for this concentration of wheel load repetitions, the design should be based on total number of commercial vehicles in both direction.

b) **Two-lane single carriage roads/ Intermediate lane roads:** The design should be based on 75 percent of the total number of commercial vehicles in both directions.

c) **Four-lane single carriageway roads:** The design should be based on 40 percent of the total number of commercial vehicles in both directions.

d) **Dual carriageway roads:** The design of dual two lane carriageway roads should be based on 75 percent of the number of commercial vehicles in each direction. For dual three-lane carriageway and dual four lane carriageway, the distribution factor will be 60 percent and 45 percent respectively.

Computation of Design Traffic
The design traffic is considered in terms of cumulative number of standard axles (in the particular lane carrying maximum traffic) to be carried during the design life of the pavement. This can be computed as:

$$N = \frac{365*[(1+r)^n - 1]}{r} * A * D * F$$

Where,
N = the cumulative number of standard axles to be catered for design in terms of msa
A = Initial traffic in the year of completion of construction in terms of number CVPD
D = Lane distribution factor
F = Vehicle damage factor (taken as shown in above table)
n = Design life in years = 15 years
r = Annual growth rate of commercial vehicle (7%)

The traffic in the year of completion is estimated using the following formula:
$A = P*(1+r)^n$

Where,

A = Initial traffic in the year of completion of construction in terms of number CVPD

P = Number of commercial vehicles per day as per last count

r = Annual growth rate of commercial vehicle

n = Number of years between the last count and the year of completion of construction

Pavement Thickness Design Chart

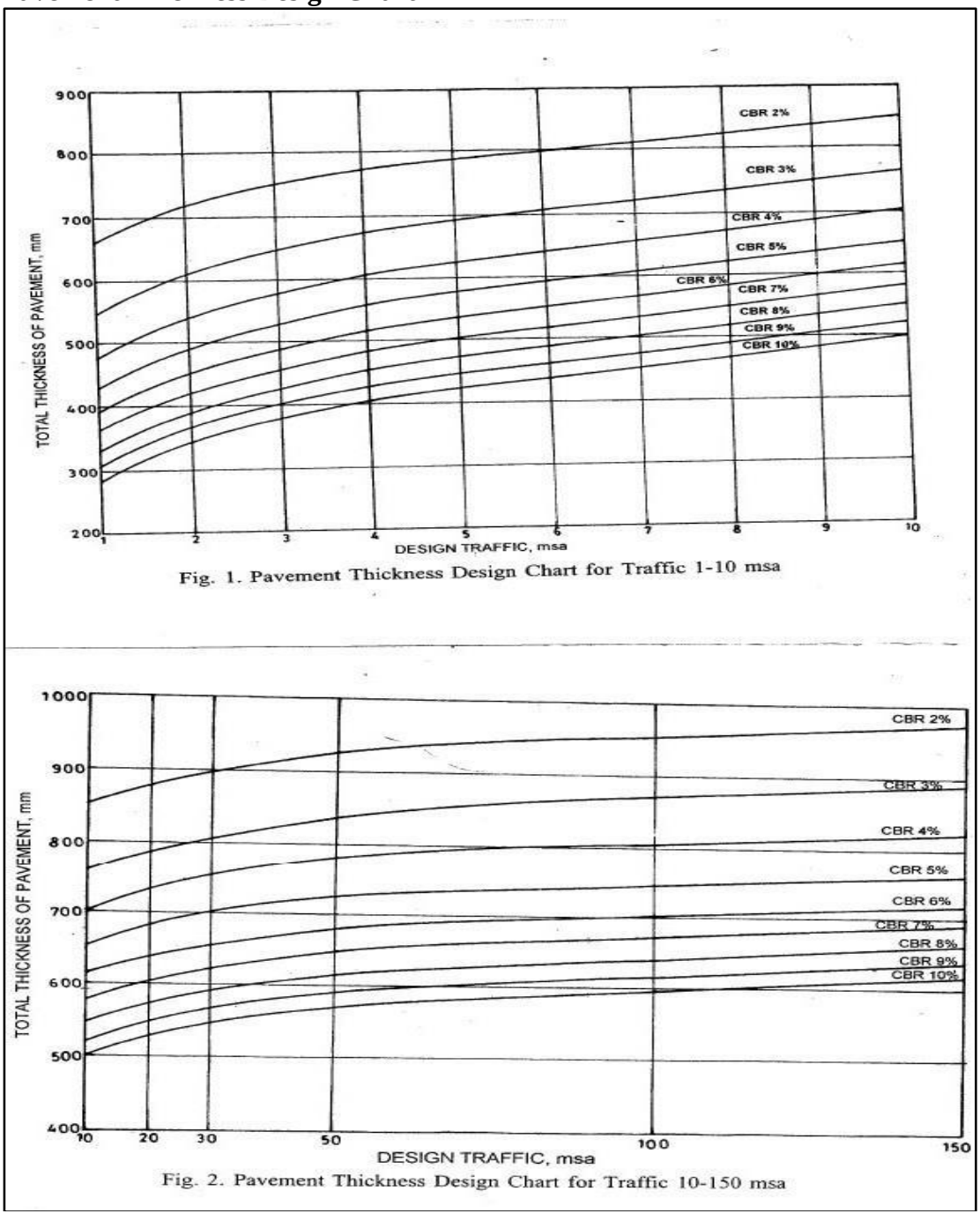


Fig. 1. Pavement Thickness Design Chart for Traffic 1-10 msa

Fig. 2. Pavement Thickness Design Chart for Traffic 10-150 msa

Figure: Pavement Thickness Design Chart

Design Calculation of Design Traffic and Cummulative Number of Standard Axles as per IRC Method

Table: Calculation of Cummulative Number of Standard Axles by IRC Method

S.N.	Vehicle	Type	2017 Traffic Count (Both Direction)	Growth Rate 7% (Trend Analysis)	2020 Traffic Forecast with 7% Growth Rate	Divert from Other Roads	Sum of Normal + Diverted Traffic	Generated Traffic due to Road Improvement (for 15 Years) (Assumed)	Total ADT	AADT 2020 (A) with seasonal factor 0.91	VDF (F)	Lane Distribution Factor (D)	A*F*D	Cumulative Number of Standard Axles (N)	Remarks
1	Truck	Multi-Axle	0	0.07	0	0	0	0	0	0	6.5	0.75	0	0	
2		Heavy	9	0.07	11	5	16	8	24	22	4.75	0.75	78	715423	
3		Light	12	0.07	15	9	24	12	36	33	1	0.75	25	229302	
4	Bus	Big	0	0.07	0	0	0	0	0	0	0.5	0.75	0	0	
5		Mini	15	0.07	18	7	25	7	32	29	0.35	0.75	8	73377	
6		Micro	17	0.07	21	12	33	11	44	40	0.35	0.75	11	100893	
7	Tractors	Tractors	25	0.07	31	18	49	15	64	58	1	0.75	44	403572	
	Total													1522567	
Cumulative Number of Standard Axles for design period (N)														**1522567**	**esa**
Cumulative Number of Standard Axles for design period (N)														**1.52**	**msa**

Cummulative Number of Standard Axles for design period is taken as **1.52≈2 msa** which lies between 1 to 10 msa.

Pavement design for this project according IRC Method of Pavement Design Guideline is Plate I – Recommended Design for Traffic 2 msa for CBR Value 9%& 10%. According to that Plate I, the total pavement thickness is 425 mm with 20 mm Plane Concrete, wearing course 50 BM and, Granular Base 225 mm and Granular Sub-base 150 mm.

Pavement Design Catalogue

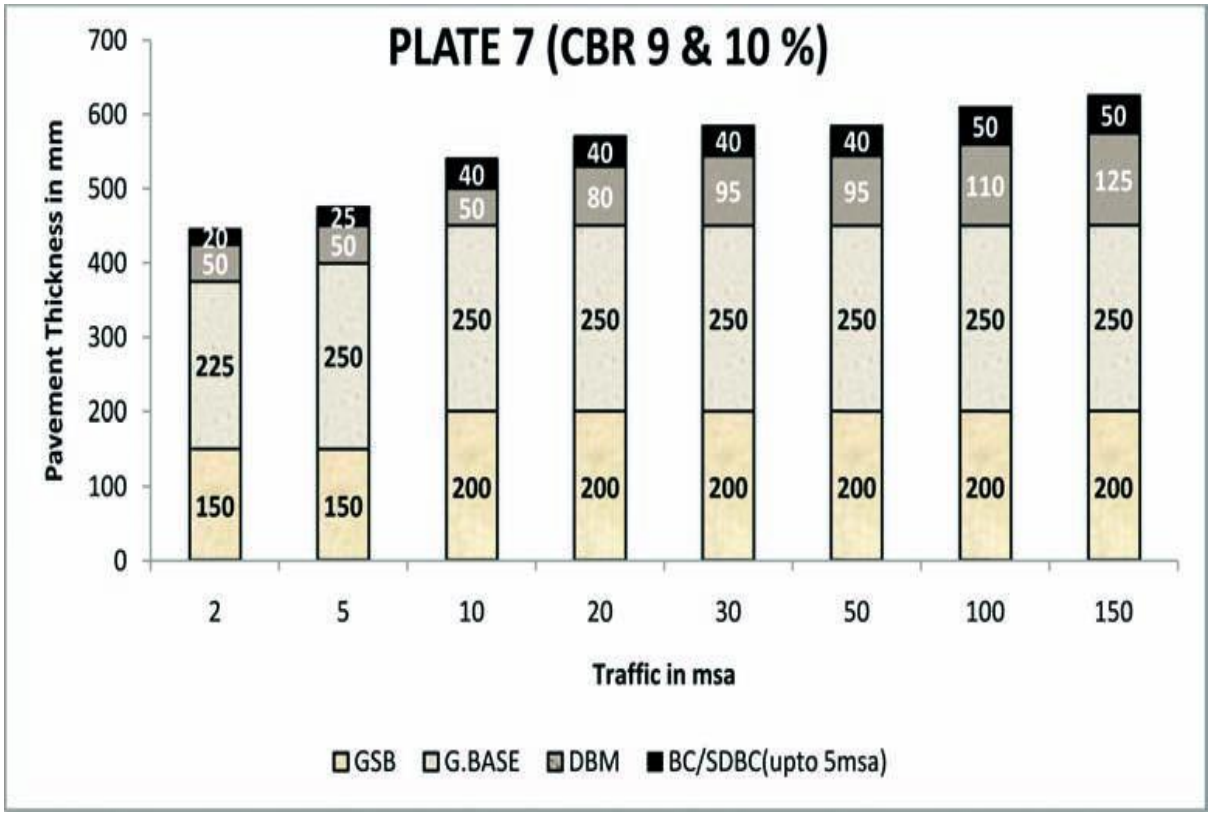


Figure: Pavement Composition and Thickness

Pavement Thickness and Composition

Pavement design for this project according IRC Method of Pavement Design Guideline is Plate I – Recommended Design for Traffic 2 msa for CBR Value 9%& 10%. According to that Plate I, the total pavement thickness is 445 mm with 20 mm Plane Concrete, wearing course 50 BM and, Granular Base 225 mm and Granular Sub-base 150 mm

3.4.3 TRL Overseas Road Note 31 Method

This Road Note gives recommendations for the structural design of bituminous surfaced roads in tropical and subtropical climate. It is aimed at highway engineers responsible for the design and construction of new road pavements and is appropriate for roads which are required to carry upto 30 cumulative equivalent standard axles in one direction.

Design Procedure

There are three main steps to be followed in designing a new road pavement. These are

i. Estimating the amount of traffic and the cumulative number of equivalent standard axles that will use the road over the selected design life.

ii. Assessing the strength of the sub-grade soil over which the road is to be built.

iii. Selecting the most economical combination of pavement materials and layer thickness that will provide satisfactorily service over the design life of the pavement using structural catalogues

Traffic

The deterioration of paved roads caused by traffic results from both the magnitude of the individual wheel loads and the number of times these loads are applied. For pavement design purposes, it is necessary to consider not only the total number of vehicles that will use the road but also the wheel loads (or for convenience, the axle loads) of these vehicles. The loads imposed by private cars do not contribute significantly to the structural damage. For the purposes of structural design, cars and similar sized vehicles can be ignored and only the total number and the axle loading of the heavy vehicles that will use the road during its design life need to be considered in this context, heavy vehicles are defined as those having a laden weight of 3000 kg or more.

Design Life

For most road projects an economic analysis period of between 10 and 20 years from the date of opening is appropriate. Design life doesn't mean at the end of the period the pavement will be completely worn out and in need of reconstruction. It means towards the end of the period the pavement will need to be strengthened so that it can continue to carry traffic satisfactorily for a further period.

Estimating Traffic Flows

In order to determine the total traffic over the design life of the road, the first step is to estimate baseline traffic flows. The estimate should be Annual Average Daily Traffic currently using the route. The AADT is defined as the total annual traffic summed for both directions and divided by 365. For long projects, large differences in traffic along the road may make it necessary to estimate the flow at several locations. It should be noted that for structural design purposes the traffic loading in one direction is required and for this reason care is always required when interpreting ADT figures.

Traffic Counts

The counts are for seven consecutive days. The counts on some of the days are for a full 24 hours, some days 16-hour counts should be sufficient. These should be grossed upto 24-hour values in the same proportion as the 16-hour/24 hour split on those days when full 24 hours

counts have been taken. Counts are avoided at times when travel activity is abnormal for short period. If possible 7-day counts should be repeated several times throughout the year.

Traffic Forecasting

An extent of future traffic depends on many factors such as economic, land-use and demographic factors. Therefore, traffic forecasting is an uncertain process. In a developing economy the problem becomes more difficult because such economies are often very sensitive to the world prices of just one or two commodities. In order to forecast traffic growth it is necessary to separate traffic into the following three categories.

a) Normal Traffic

Traffic which will pass along the existing road or track even if no any new pavement is provided. The commonest method of forecasting normal traffic is to extrapolate time series data on traffic levels and assume that growth will either remain constant in absolute terms i.e. a fixed number of vehicles per year (a linear extrapolation), or constant in relative terms i.e. a fixed percentage increase.

b) Diverted Traffic

Traffic that changes from another route (or mode of transport) to the project road because of the improved pavement, but still travels between the same origin and destination. Where parallel routes exist, traffic will usually travel on the quickest route although this may not necessarily be the shortest. Thus, surfacing an existing road may divert traffic from a parallel and shorter route because higher speeds are possible on the surface road. Origin and destination surveys should be carried out to provide data on the traffic diversions likely to arise. Diverted traffic is normally assumed to grow at the same rate as traffic on the road from it is diverted.

c) Generated Traffic

Additional traffic which occurs in response the provision or improvement of the road. Generated traffic arises either because a journey becomes more attractive by virtue of a cost or time reduction or because of the increased developments that is brought about by the road investment. Generated traffic is difficult to forecast accurately and can be easily overestimated. It is only likely to be significant in those cases where the road investment brings about large reductions in transport costs. For example, in the case of a small improvement within an already developed highway system, generated traffic will be small and can normally be ignored. However, in the case of a new road allowing access to a undeveloped area, there could be large reductions in transport costs as a result of changing mode from, for example, animal based transport to motor vehicle transport. In such a case, generated traffic could be the main component of future traffic flow.

Note: As traffic forecast is made for 20 years after completion of road construction with 7% annual growth rate and as road is existing and only improvement and up gradation is being done in this road project, it is assumed that 7% growth rate in normal traffic will accommodate for diverted and generated traffic so no any separate calculation is made for diverted and generated traffic.

Axle Loading

The damage that vehicles do to a road depends very strong on the axle load of the vehicles. For pavement design purposed, the damaging power of axles is related to a Standard Axle of 8.16 tones using equivalence factors which have been derived from empirical studies.

Axle Load Survey

If no recent axle load data are available, it is recommended that axle load surveys of heavy vehicles are undertaken whenever a major road project is being damaged. Axle load surveys are carried out by weighing a sample vehicle at the road side. The sample should be chosen such that a maximum of about 60 vehicles per hour are weighed. The mean equivalence factor for each type of class of vehicle travelling in each direction must then be determined

Cumulative Equivalent Standard Axles

The daily traffic flow for each class of vehicle and the average daily one directional flow for each class of vehicle is determined first. Then a forecast of the one directional traffic flow for each class of vehicle during design life is made. Then, the mean equivalence factor of each class of vehicle and for each direction from the results of this axle load survey. Finally the higher of the two directional values should be used for design.

Equivalent Factors for Different Axle Loads

Equivalent factors for different axle loads are given in table below:

Table: Equivalent factors for different axle loads

S.N.	Wheel Load (single and dual) (10^3 kg)	Axle Load (10^3 kg)	Equivalence Factor
1	1.5	3.0	0.01
2	2.0	4.0	0.04
3	2.5	5.0	0.11
4	3.0	6.0	0.25
5	3.5	7.0	0.50
6	4.0	8.0	0.91
7	4.5	9.0	1.55
8	5.0	10.0	2.50
9	5.5	11.0	3.83
10	6.0	12.0	5.67
11	6.5	13.0	8.13
12	7.0	14.0	11.30
13	7.5	15.0	15.50
14	8.0	16.0	20.70
15	8.5	17.0	27.20
16	9.0	18.0	35.20
17	9.5	19.0	44.90
18	10.0	20.0	56.50

Vehicle Damage Factor

Where sufficient information on axle load is not available and project size does not warrant conducting an axle load survey, the indicative values of Vehicle damage factor (VDF) may be used as given in the table below. The Vehicle Damage factor (VDF) is the multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions. It is defined as equivalent number of standard axle per commercial vehicle. The VDF varies with the vehicle axle configuration, axle loading, and terrain type and from region to region. The VDF is arrived at axle load surveys on typical sections so as to cover various influencing factors, such as traffic mix, mode of

transportation, commodities carried, time of the year, terrain, road conditions and degree of enforcement.

Table: Vehicle Damage Factor

S.N.	Vehicle Type	VDF
1	Heavy truck (three axle or more)	6.50
2	Heavy two axle	4.75
3	Mini truck/tractor	1.0
4	Large bus	0.50
5	Bus	0.35
6	Tractors	1.0

Traffic Classes

Following given below table shows various traffic classes as per equivalent standard axles

Table:1 Traffic Classes and Equivalent Standard Axles Range

S.N.	Traffic Classes	Range (10^6 esa)
1	T1	< 0.3
2	T2	0.3 – 0.7
3	T3	0.7 – 1.5
4	T4	1.5 – 3.0
5	T5	3.0 – 6.0
6	T6	6.0 – 10.0
7	T7	10.0 – 17.0
8	T8	17.0 – 30.0

Subgrade Strength Classes

Following given below table shows various subgrade strength classes as per CBR %.

Table: Subgrade Strength Classes as per CBR % Range

S.N.	Subgrade Strength Classes	Range (CBR %)
1	S1	< 2
2	S2	3 - 4
3	S3	5 - 7
4	S4	8 - 14
5	S5	15 - 29
6	S6	> 30

Computation of Design Traffic

The design traffic is considered in terms of cumulative number of standard axles (in the particular lane carrying maximum traffic) to be carried during the design life of the pavement. This can be computed as:

$$N = \frac{365*[(1+r)^n - 1]}{r} * A * D * F$$

Where,

N = The cumulative number of standard axles to be catered for design in terms of msa
A = Initial traffic in the year of completion of construction in terms of number CVPD
D = Lane distribution factor
F = Vehicle damage factor (taken as shown in above table)
n = Design life in years = 15 years
r = Annual growth rate of commercial vehicle (7%)

The traffic in the year of completion is estimated using the following formula:

$A = P*(1+r)^n$

Where,

A = Initial traffic in the year of completion of construction in terms of number CVPD
P = Number of commercial vehicles per day as per last count
r = Annual growth rate of commercial vehicle (7%)
n = No. of years between the last count and year of completion of construction (3 years)

Design Calculation of Design Traffic and Cummulative Number of Standard Axles as per TRL Overseas Road Note 31

Table: Cummulative Number of Standard Axles from Road Note 31

S.N.	Vehicle	Type	2017 Traffic Count (Both Direction)	Growth Rate 7% (Trend Analysis)	2020 Traffic Forecast with 7% Growth Rate	Divert from Other Roads	Sum of Normal + Diverted Traffic	Generated Traffic due to Road Improvement (for 15 Years) (Assumed)	Total ADT	AADT 2020 (A) with seasonal factor 0.91	VDF (F)	Lane Distribution Factor (D)	A*F*D	Cumulative Number of Standard Axles (N)	Remarks
1	Truck	Multi-Axle	0	0.07	0	0	0	0	0	0	6.5	0.75	0	0	
2		Heavy	9	0.07	11	5	16	8	24	22	4.75	0.75	78	715423	
3		Light	12	0.07	15	9	24	12	36	33	1	0.75	25	229302	
4	Bus	Big	0	0.07	0	0	0	0	0	0	0.5	0.75	0	0	
5		Mini	15	0.07	18	7	25	7	32	29	0.35	0.75	8	73377	
6		Micro	17	0.07	21	12	33	11	44	40	0.35	0.75	11	100893	
7	Tractors	Tractors	25	0.07	31	18	49	15	64	58	1	0.75	44	403572	
	Total													1522567	
Cumulative Number of Standard Axles for design period (N)														**1522567**	**esa**
Cumulative Number of Standard Axles for design period (N)														**1.52**	**msa**

Cummulative Number of Standard Axles for design period is calculated as 1.52≈2 msa.

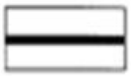
According to Road Note 31, studied road is classified as Traffic Class T4 with value 1.52≈2 msa which lies between (1.5-3.0) msa and Subgrade Strength Class as S4 with CBR value 11% which is ranges between (8-14)%. Therefore according to structural catalogue of Road Note 31, the combination is T4 and S4. According to Road Note 31, the total pavement thickness is 400 mm with SD, Granular Base 200 mm and Granular Sub-base 200 mm.

Pavement Composition Chart as per TRL Overseas Road Note 31

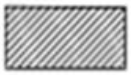
KEY TO STRUCTURAL CATALOGUE

Traffic classes (10^6 esa)	Subgrade strength classes (CBR%)
T1 = < 0.3	S1 = 2
T2 = 0.3 - 0.7	S2 = 3 , 4
T3 = 0.7 - 1.5	S3 = 5 - 7
T4 = 1.5 - 3.0	S4 = 8 - 14
T5 = 3.0 - 6.0	S5 = 15 - 29
T6 = 6.0 - 10	S6 = 30+
T7 = 10 - 17	
T8 = 17 - 30	

Material Definitions

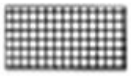

Double surface dressing


Flexible bituminous surface


Bituminous surface
(Usually a wearing course, WC, and a basecourse, BC)


Bituminous roadbase, RB


Granular roadbase, GB1 - GB3


Granular sub-base, GS


Granular capping layer or selected subgrade fill, GC


Cement or lime-stabilised roadbase 1, CB1


Cement or lime-stabilised roadbase 2, CB2


Cement or lime-stabilised sub-base, CS

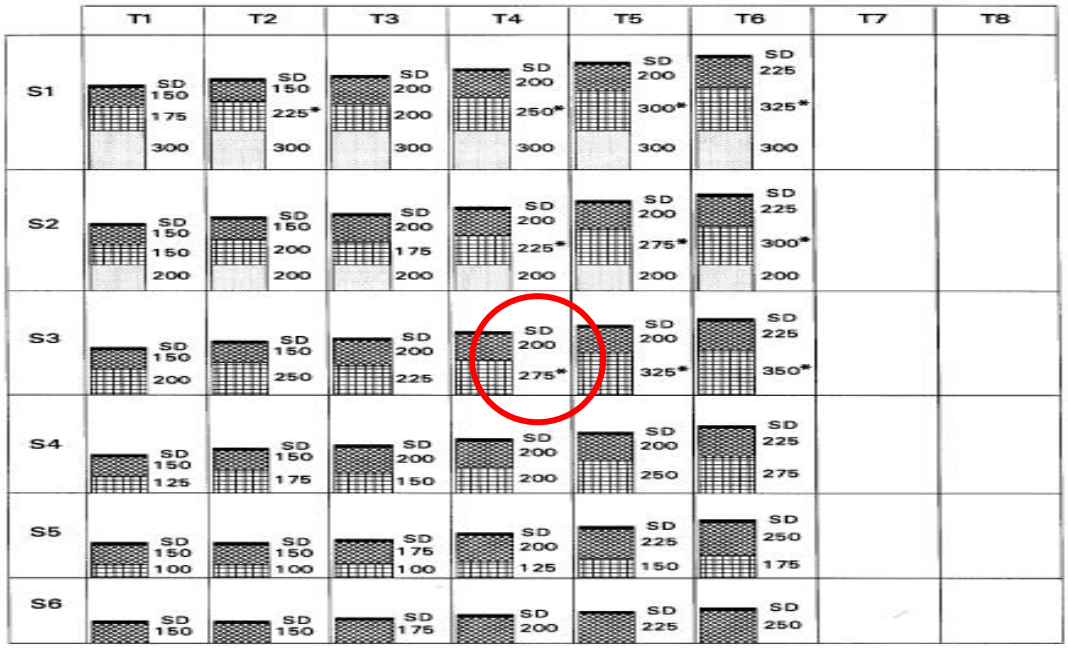


Figure: Chart 1 Road Pavement Composition as per Road Note 31

Overall Conclusion and Recommendation for Design of Pavement:

For this project, we design the pavement by following three methods:

1. DoR Pavement Design Guidelines Method (Flexible Pavement)
2. IRC Method
3. TRL Overseas Road Note 31 Method

1.DoR Pavement Design Guidelines Method (Flexible Pavement)

Chainage		CBR from DCPT	Design CBR for Pavement Design Guideline	Calculated MSA	Adopted MSA	Caping Layer	Road Sub-Base	Road Base	Surface Dressing
From	To								
0+000	32+680	11	10	1.52	2	0	150	150	DBSD with 20/14mm and 10/6mm aggregate

2.IRC Method

Chainage		CBR from DCPT	Design CBR for Pavement Design Guideline	Calculated MSA	Adopted MSA	Caping Layer	Road Sub-Base	Road Base	Surface Dressing
From	To								
0+000	32+680	11	10	1.52	2	0	150	225	DBSD with 20/14mm and 10/6mm aggregate

3.TRL Overseas Road Note 31 Method

Chainage		CBR from DCPT	Subgrade Strength Class	Calculated MSA	Adopted MSA	Caping Layer	Road Sub-Base	Road Base	Surface Dressing
From	To								
0+000	32+680	11	***S4***	1.52	***T4***	0	200	200	DBSD with 20/14mm and 10/6mm

									aggregate

Among three methods, TRL Overseas Road Note 31 Method seems more optimum. So, we recommend TRL Overseas Road Note31 method.

Chainage		CBR from DCPT	Subgrade Strength Class	Calculated MSA	Adopted MSA	Capin g Layer	Road Sub-Base	Road Base	Surface Dressing
From	To								
0+000	32+680	11	***S4***	1.52	***T4***	0	200	200	DBSD with 20/14mm and 10/6mm aggregate

3.5 Traffic Safety and Controllers

Different kinds of traffic controllers and safety precautions and undertaken during the study and design of this road and estimated cost is also included in the total project cost. Following things are undertaken during this study.

- Placing of different traffic sign post at various chainages as required.
- Placing of km post at various chainages as required (per one km and per five km).
- Placing of RCC delineator and guard post at various places as required.
- Traffic Controller and diversions are provided as required

Supplying and fixing in place R.C.C. delineator post

ROAD FURNITURE AND TRAFFIC SAFETY MEASURES

S.N.	Designed Ch.		Quantity (No)	Description	Remarks
	Towards End	Towards Start			
1	0+540	0+440	2	Sharp Bend	
2	1+000	0+920	2	Sharp Bend	
3	1+820	1+760	2	Sharp Bend	
4	1+960	1+920	2	Sharp Bend	
5	4+360	4+280	2	Sharp Bend	
6	7+240	7+200	2	Sharp Bend	
7	7+600	7+520	2	Sharp Bend	
8	8+000	7+800	2	Sharp Bend	
9	11+000	10+960	2	Sharp Bend	
10	11+200	11+100	2	Sharp Bend	
11	13+220	13+160	2	Sharp Bend	
12	14+200	14+140	2	Sharp Bend	
13	14+400	14+320	2	Sharp Bend	
14	16+660	16+600	2	Sharp Bend	
15	17+460	17+420	2	Sharp Bend	
16	18+140	18+100	2	Sharp Bend	
17	18+540	18+440	2	Sharp Bend	
18	18+940	18+880	2	Sharp Bend	
19	19+240	19+180	2	Sharp Bend	
20	21+840	21+420	7	Continuous Curve	
21	22+460	22+380	2	Sharp Bend	
22	22+800	22+640	7	Hair Pin Bend	
23	25+660	25+200	7	Continuous Curve	
24	26+580	26+500	2	Sharp Bend	
25	27+020	26+980	2	Sharp Bend	
26	27+440	27+340	2	Sharp Bend	
27	31+380	31+320	2	Sharp Bend	
28	31+960	31+580	7	Hair Pin Bend	

			100	Provisional	
		Total	**176**	**no.**	

Item No.: 6.02

Description of work: Supplying and placing Stone Marker (R.C.C. kilometer post)

6.02 a) Standard kilometer marker stone (placed at each km distance).

S.N.	Designed Ch.		Quantity (No)	Remarks
	From	To		
1	0+000	32+680	27	
		Total	**27**	**no.**

6.02 b) 5th kilometer marker stone (placed at each 5 km distance).

S.N.	Designed Ch.		Quantity (No)	Remarks
	From	To		
1	0+000	32+680	7	
		Total	**7**	**no.**

Item No.: 6.03

Description of work: Supplying and fixing in place R.C.C. delineator post

S.N.	Designed Ch.		Quantity (No)	Remarks	
	To	From			
1	0+540	0+440	15	Sharp Bend	
2	1+000	0+920	7	Sharp Bend	
3	1+820	1+760	10	Sharp Bend	
4	1+960	1+920	7	Sharp Bend	
5	4+360	4+280	10	Sharp Bend	
6	7+240	7+200	7	Sharp Bend	
7	7+600	7+520	10	Sharp Bend	
12	8+000	7+800	30	Sharp Bend	
13	11+000	10+960	7	Sharp Bend	
14	11+200	11+100	15	Sharp Bend	
15	13+220	13+160	10	Sharp Bend	
16	14+200	14+140	7	Sharp Bend	
17	14+400	14+320	10	Sharp Bend	
18	16+660	16+600	7	Sharp Bend	
19	17+460	17+420	7	Sharp Bend	
20	18+140	18+100	7	Sharp Bend	
21	18+540	18+440	15	Sharp Bend	
22	18+940	18+880	10	Sharp Bend	
23	19+240	19+180	10	Sharp Bend	
24	21+840	21+420	30	Continuous Curve	
25	22+460	22+380	10	Sharp Bend	
26	22+800	22+640	25	Hair Pin Bend	
27	25+660	25+200	30	Continuous Curve	
28	26+580	26+500	10	Sharp Bend	
29	27+020	26+980	7	Sharp Bend	
30	27+440	27+340	15	Sharp Bend	
31	31+380	31+320	10	Sharp Bend	
32	31+960	31+580	20	Hair Pin Bend	
			250	Provisional	
		Total	**608.00**	**Nos.**	

CHAPTER 4: DETAILED ENGINEERING SURVEY

4.1 The Survey Team

The survey team for detailed survey work of proposed road constitute of engineers, senior surveyors, junior surveyors and other assistants.

4.2 Pre-survey Activities

Before the commencement of the detailed survey, a brief desk study was carried out by the team of consultant to be familiar with the site. During the desk study work, various reports were reviewed. Before the commencement of the survey work, a meeting of the consultant team and Client was conducted. The meeting was conducted to make the consultant team familiar with the project area. During the meeting, the consultant team was introduced about the project road, its accessibility, existing condition of the road, etc.

4.3 Topographical Survey

Strip Survey was conducted for the proposed alignment. This method of survey is done for new alignment or existing alignment where change in alignment is necessary. In this method of survey, survey is done of strip of proposed alignment. The second stage detail survey of the road alignment was conducted to prepare topography maps.

In case of existing tracks and trails, detail survey will be conducted only in case of realignment is required or the places of stream crossing, landslides etc. Exact need of detail topography survey in case of upgrading sections will be established in the field and survey will be carried out accordingly.

The detail survey of the road alignment will be carried out covering details within the right of way and to prepare maps to include:
Contours at 0.5 to 1m interval as appropriate considering the nature of terrain;
Settlement / villages including government, private and public establishments;
Traverse lines, BMs and other survey control points;
River / stream crossings, gullies and other drainage crossings;
Topography features such as ridges, depressions, valleys, summits, cliffs;
Other information pertinent to design, construction and maintenance of roads.

4.4 Fixing of Gradient between Consecutive Control Points

In order to control the vertical gradient of road alignment between two consecutive control points, this survey is conducted. This will be done with the help of abbey level, ranging rod and tape.

4.5 Establishment Bench Marks and Control Points

Permanent Bench Marks were established along the road alignment at about 500m intervals. Permanent objects along the alignment were given the first priority for establishment of BM. If permanent objects were not available, then concrete pegs with a nail at the top were mounted as BM. The BMs will provide vertical control points for the survey and also serve as baseline stations and traverse points for horizontal ground control. At least three reference points were provided for each BM and Description Cards has been prepared which helps in locating the BM during construction phase.

4.6 Bench Mark Survey

Bench mark survey was carried out by running a double run, second order split level circuits. All closing errors are kept within the acceptable limits of second order accuracy.

4.7 Baseline Survey

In order to provide horizontal control for the engineering survey, baseline survey was conducted. A closed baseline survey was carried out by the help of Total Station. Visibility guided the distance between the two consecutive baseline points.

4.8 Traverse Survey

A primary traverse survey was carried out along the road alignment. The survey was connected to the baseline survey so that both have a single coordinate system. The survey covered the right of way and recorded location of existing and proposed centre line, BMs and TBMs, physical and manmade features of permanent nature, which might influence the road alignment.

4.9 Data Entry and Analysis

The survey conducted for the proposed road was of strip survey method. In order to obtain the existing grade and nature of terrain, longitudinal and cross section survey was conducted by pegging the chainage point at every 20m interval. The cross section survey was extended to a distance of 25m.

The traverse survey was conducted with the help of Total Station. The coordinate of the first traverse point was computed from the available topo map of Department of Survey. Strip survey was conducted for the proposed road. The traverse was closed at the various locations for obtaining the higher accuracy. Bench Mark was fixed at about 500 m interval and level was closed at every BM points. The reading of level machine was entered in the Excel to compute the elevation of each peg points and cross section points.

SW Road and **Smart Road** Software was used for the designing of alignment. Detail data was entered in Excel and contour was drawn in AutoCAD with the help of **SW DTM and Smart Road DTM Loader**. Fixing of alignment was done as per the nature of contour. Wherever possible, existing track was followed and change of alignment was done only where the grade was very steep.

CHAPTER 5: ENGINEERING STUDY AND INVENTORY SURVEY

5.1 General

Following field surveys and investigations have been carried out for the project roads to determine the appropriate inputs for design and project preparation.

1. Road Inventory Survey
2. Construction Material Survey
3. Geological and Geo-technical Survey
4. Hydrological and Meteorological Survey

5.2 Road Inventory Survey

Field surveys have been carried out to record road inventory details of the project roads. Following surveys have been carried out:

- Sub-grade condition survey (visual survey)
- Existing structure survey
- Side drains requirement survey
- Cross drainage requirement survey
- Retaining and protection work requirement survey
- Land use survey
- The location of settlements of the road structures, electric poles, streams, water taps within the area of the plan.

5.2.1 GPS Co-ordinate of Major Location:

Table: GPS Co-ordinate of Major Locations

Starting Point:	Khadketari, Syangja District
	Latitude : 27°30'56.13"N
	Longitude : 83°36'4.11"E
	Elevation : 98.498 AMSL
End Point:	Dobilla, Syangja District
	Latitude : 27°27'42.85"N
	Longitude : 83°13'31.82"E
	Elevation : 81.529 m AMSL

5.2.2 Visual survey of topography/condition of existing road and structure:

Table: Visual Survey of Topography

Chainage		Types of Soil
From	To	
0+000	0+500	OS-60BMS-40
0+500	1+050	OS-30BMS-65MR-5
1+050	1+120	BMS-40MR-50HR-10
1+120	1+500	OS-30BMS-60MR-10
1+500	2+000	OS-40BMS-50MR-10
2+000	2+500	OS-40BMS-40MR-15HR-5

Chainage		Types of Soil
From	To	
2+500	3+500	OS-30BMS-65MR-5
3+500	4+000	OS-30BMS-60MR-5HR-5
4+000	5+000	OS-60BMS-40
5+000	6+700	OS-40BMS-50MR-10
6+700	7+500	OS-70BMS-30
7+500	8+500	OS-40BMS-50MR-10
8+500	10+000	OS-30BMS-65MR-5
10+000	11+000	OS-40BMS-50MR-10
11+000	12+500	OS-40BMS-60
12+500	15+000	OS-60BMS-40
15+000	16+500	OS-50BMS-40MR-10
16+500	17+500	OS-40BMS-50MR-5HR-5
17+500	18+500	OS-60BMS-40
18+500	19+000	OS-40BMS-40MR-15HR-5
19+000	19+500	OS-50BMS-40MR-10

5.2.3 Land Use and Settlement Pattern Survey:

Table: Land Use and Settlement Pattern Survey

Chainage		**Remarks**
To	**From**	
0+000	0+700	Settlement & Cultivated Area
0+700	1+100	Cultivated +Forest
1+100	1+500	Settlement & Cultivated Area
1+500	2+890	Settlement
2+890	3+900	Settlement & Jungle
3+900	8+000	Community Forest
8+000	10+650	Settlement & Cultivated Area
10+650	11+500	Community Forest
11+500	12+350	Barren hill
12+350	12+950	Settlement & Cultivated Area
12+950	13+700	Cultivated Area & Jungle
13+700	14+150	Settlement & Jungle
14+150	15+750	Settlement & Cultivated Area
15+750	16+000	Cultivated Area
16+000	17+400	Settlement & Cultivated Area
17+400	18+100	Settlement &Jungle
18+100	18+800	Jungle& Barren Land
18+800	19+750	Settlement & Cultivated Area
19+750	20+400	Barren Land

20+400	22+350	Jungle&Cultivated Area
22+350	23+400	Settlement & Cultivated Area
23+400	25+200	Jungle
25+200	28+100	Settlement & Cultivated Area
28+100	28+800	Cultivated Area
28+800	32+100	Settlement & Cultivated Area
32+100	32+681	Jungle

5.2.4 Side Drain Requirement:

Table: Side Drain Requirement

S.N	Types of Drain	Total Length	
		Left	Right
1	DRAINF	10380	21060
2	DRAIND	240	880
3	DRAINE	0	120

5.2.5 Masonry Retaining Wall Requirement

Table- Location of Proposed Masonry Retaining Wall

Chainage	Length	Left		Right	
		MWRET	Height	MWRET	Height
3+920	20			MWRETA	2.2
4+000	20			MWRETA	2.7
4+040	20			MWRETA	2.4
4+580	20			MWRETA	2
4+600	20			MWRETA	2.5
4+620	20			MWRETA	2.5
5+480	20	MWRETA	2		
6+500	20	MWRETA	2.2		
9+800	20	MWRETA	2.5		
10+720	20	MWRETA	3		
11+100	20			MWRETA	2.8
11+360	20	MWRETA	3		
11+520	20	MWRETA	2.7		
11+540	20	MWRETA	3.7		
11+580	20	MWRETA	3		
11+600	20	MWRETA	3.5		
11+620	20	MWRETA	4.7		
11+640	20	MWRETA	3.5		
11+660	20	MWRETA	3		
11+680	20	MWRETA	3		
12+180	20	MWRETA	2.7		
12+200	20	MWRETA	2.7		
12+220	20	MWRETA	2.7		

Chainage	Length	Left		Right	
		MWRET	Height	MWRET	Height
12+240	20			MWRETA	3.4
12+280	20	MWRETA	2.5		
12+320	20	MWRETA	2.5		
12+420	20	MWRETA	2		
12+480	20	MWRETA	3		
12+600	20	MWRETA	2.7		
12+720	20	MWRETA	2.5		
12+800	20	MWRETA	2.5		
13+280	20	MWRETA	2		
13+300	20	MWRETA	2		
13+400	20	MWRETA	2.2		
14+060	20	MWRETA	2.8		
14+080	20	MWRETA	2.8		
14+100	20	MWRETA	2.5		
14+400	20	MWRETA	2.5		
14+440	20	MWRETA	2.4		
15+960	20	MWRETA	2.2		
17+160	20	MWRETA	3		
17+260	20	MWRETA	3		
17+300	20	MWRETA	3		
20+680	20	MWRETA	2		
20+700	20	MWRETA	2		
20+720	20	MWRETA	4		
20+740	20	MWRETA	3		
20+800	20	MWRETA	3		
21+540	20			MWRETA	3.5
22+140	20			MWRETA	3
22+340	20	MWRETA	3.7		
22+920	20	MWRETA	3		
22+940	20	MWRETA	3		
22+960	20	MWRETA	3		
23+060	20	MWRETA	3.4		
23+080	20	MWRETA	3.4		
23+100	20	MWRETA	2.5		
23+280	20	MWRETA	3.5		
23+340	20	MWRETA	3		
23+400	20	MWRETA	2.4		
24+260	20	MWRETA	4.5		
24+280	20	MWRETA	3.5		
24+300	20	MWRETA	2.5		
24+680	20	MWRETA	3		
24+820	20	MWRETA	3		
25+360	20			MWRETA	4.5
25+380	20			MWRETA	4
25+400	20			MWRETA	2.5
25+480	20	MWRETA	4		
25+500	20	MWRETA	3.4		

Chainage	Length	Left		Right	
		MWRET	Height	MWRET	Height
25+520	20	MWRETA	3.7		
25+540	20	MWRETA	3.2		
25+680	20			MWRETA	2.7
25+700	20			MWRETA	3
25+900	20	MWRETA	2		
25+920	20	MWRETA	2		
25+940	20	MWRETA	3.5		
25+960	20	MWRETA	3.7		
25+980	20	MWRETA	5		
26+020	20			MWRETA	3.5
26+040	20			MWRETA	3.2
26+060	20			MWRETA	3
26+580	20			MWRETA	2.5
26+680	20	MWRETA	2		
26+700	20	MWRETA	3		
26+720	20	MWRETA	3		
27+040	20	MWRETA	2		
27+060	20	MWRETA	3		
27+460	20			MWRETA	2.4
28+400	20			MWRETA	2.5
28+420	20			MWRETA	3
28+440	20			MWRETA	2.5
29+860	20	MWRETA	3		
29+880	20	MWRETA	3		
31+800	20	MWRETA	3.5		
31+860	20			MWRETA	4
31+900	20			MWRETA	2.5
31+920	20			MWRETA	3
31+960	20	MWRETA	3		
32+040	20	MWRETA	3		
32+080	20	MWRETA	3		
32+180	20	MWRETA	2.5		
32+300	20	MWRETA	2.7		
32+320	20	MWRETA	2.7		
32+340	20	MWRETA	3		
32+360	20	MWRETA	3.5		
32+380	20	MWRETA	3.5		
32+400	20	MWRETA	4		
32+420	20	MWRETA	3.5		
32+660	20	MWRETA	2.2		

5.2.6 Masonry Breast Walls Requirement

Table Location of Proposed Masonry Breast Walls

Chainage	Length	Left		Right	
		MWBRT	Height	MWBRT	Height
11+580	20			MWBRTA	2.5
11+600	20			MWBRTA	2.5
11+620	20			MWBRTA	2.5
11+640	20			MWBRTA	2.5
11+660	20			MWBRTA	2.5
11+680	20			MWBRTA	2.5

5.2.7 Gabion Walls Requirement

Table 2 Location of Proposed Gabion Walls

Chainage	Length	Left		Right	
		GWRET	Height	GWRET	Height
0+520	20	GWRETC	3	GWRETC	2
0+900	20	GWRETC	2		
1+080	20			GWRETC	3
1+100	20			GWRETC	2
1+140	20			GWRETC	2
1+440	20	GWRETC	3		
1+560	20	GWRETC	3		
1+580	20	GWRETC	3		
1+600	20	GWRETC	4		
1+620	20	GWRETC	3		
1+640	20	GWRETC	3		
1+680	20	GWRETC	3		
1+700	20	GWRETC	4		
1+720	20	GWRETC	3		
2+200	20	GWRETC	3		
2+220	20	GWRETC	3		
2+600	20			GWRETC	3
2+760	20			GWRETC	3
2+820	20			GWRETC	3
2+840	20			GWRETC	3
2+860	20			GWRETC	3
2+900	20			GWRETC	3
3+360	20			GWRETC	3
3+380	20			GWRETC	3
4+680	20			GWRETC	3

Chainage	Length	Left		Right	
		GWRET	Height	GWRET	Height
4+700	20			GWRETC	3
4+720	20			GWRETC	3
4+920	20	GWRETC	2		
5+040	20	GWRETC	3		
5+300	20	GWRETC	3		
6+100	20			GWRETC	3
6+120	20			GWRETC	3
6+140	20			GWRETC	3
6+440	20			GWRETC	4
7+000	20			GWRETC	3
7+040	20			GWRETC	3
7+080	20			GWRETC	3
7+140	20			GWRETC	3
7+160	20			GWRETC	3
9+480	20	GWRETC	3		
11+140	20			GWRETC	3
11+180	20	GWRETC	3		
11+220	20	GWRETC	4		
11+440	20	GWRETC	5		
11+460	20	GWRETC	3		
11+500	20	GWRETC	4		
13+240	20	GWRETC	2		
13+740	20	GWRETC	3		
14+300	20			GWRETC	4
14+460	20	GWRETC	4		
14+480	20	GWRETC	3		
14+720	20	GWRETC	3		
14+760	20	GWRETC	4		
14+880	20	GWRETC	4		
14+920	20	GWRETC	3		
16+040	20	GWRETC	4		
16+460	20	GWRETC	4		
16+820	20	GWRETC	3		
16+940	20	GWRETC	3		
17+000	20	GWRETC	4		
17+560	20	GWRETC	3		
17+620	20	GWRETC	4		
17+640	20	GWRETC	4		
17+700	20	GWRETC	3		
17+740	20	GWRETC	3		
17+800	20	GWRETC	4		
18+060	20			GWRETC	3

Chainage	Length	Left		Right	
		GWRET	Height	GWRET	Height
18+360	20	GWRETC	4		
18+380	20	GWRETC	3		
18+600	20			GWRETC	3
18+620	20			GWRETC	4
18+720	20			GWRETC	4
18+800	20			GWRETC	3
18+840	20			GWRETC	3
18+880	20			GWRETC	3
19+000	20	GWRETC	4		
19+100	20	GWRETC	3		
19+520	20	GWRETC	3		
20+120	20	GWRETC	3		
20+420	20	GWRETC	4		
21+500	20			GWRETC	3
22+260	20	GWRETC	3		
22+380	20			GWRETC	3
22+420	20			GWRETC	3
22+440	20			GWRETC	3
24+240	20	GWRETC	3		
24+400	20	GWRETC	3		
24+560	20	GWRETC	4		
24+620	20	GWRETC	3		
24+700	20	GWRETC	4		
24+720	20	GWRETC	3		
24+840	20	GWRETC	3		
24+860	20	GWRETC	3		

5.2.7 Gabion Breast Walls Requirement

Table 3 Location of Proposed Gabion Breast Walls

Chainage	Length	Left		Right	
		GWBRT	Height	GWBRT	Height
1+880	20	GWBRTA	3		
4+920	20			GWBRTA	3
13+200	20			GWBRTA	3
15+740	20			GWBRTA	3

5.3 Construction Materials Survey

Construction Materials Survey is one of the important task that need to be carried out during project study. Construction Materials are divided into two types as Naturally Available and Factory Made Material. Following studied was made in this survey to identify and locate the required construction materials:

- Identification of potential sources
- Investigation of existing road materials on sites.

Potential Sources:

The hilly area is reach in terms of stone and sand which is major material for the road construction but in terai it is quite difficult to find out the source for stone. It is necessary to collect the information regarding the availability of materials for the construction works. Hence, study was done on the availability of construction materials and the materials to be supplied by the manufacturer.

5.3.1 Naturally Available Material

Rivers are the major source for construction materials such as aggregates, sand and gravel and need to pay some nominal tax to VDC/Municipality for using this. Alignment doesn't pass through hill area where deposition of boulders is seen which is the source for stones as well. Bhat Khola, Jare Kholais the major sources for sand and stones. We observed and recommended Four Major Quarry Sites for this project. Quarry Sites are properly shown in table below.

Table:Location of Naturally Available Material

SN	Quarry Site	Materials Available	Purpose
1	Quarry site 1 (Bhat khola)	Sand, stones, Gravels	Stone for gabions /masonary wall/ base coure/ wearing course/ RCC Structure)
2	Quarry site 2(Jare khola)	Sand, stones, Gravels	Stone for gabions /masonary wall/ base coure/ wearing course/ RCC Structure

5.3.2 Factory Made Materials

Besides naturally available material, various type of factory made materials also need to be supplied for the construction of the project. Materials like cement, steel, reinforcement bars, nails, wires, gabion wire, machineries, tools and equipments, petroleum products and other necessary materials have to supplied from near city and market areaPhedi Khola, Putalibazzar, Pokhara, are the major market and city area for this project site. Factory made materials are easily available in these cities. Incase of unavailibity, we can import these materials from Indiaas well.

5.3.3 Test Result of Construction Material Construction Material Test is performed by GOEC Nepal Pvt Ltd, New Baneshwor, Kathmandu and shows the following test Results.

Table Construction Materials Testing Results

S.N.	Quarry Site	Location	LAA	Avg. LAA	AIV	Avg. AIV	Remarks
			%	%	%	%	
1	Quarry Site 1 (Bhat Khola)	**Khadketari, Syanja**	30.83 27.5 28.33	28.89	20 20.35	20.175	Good
2	Quarry Site 2 (Jare Khola)	**Khadketari, Syanja**	27.5 29.167 30	28.89	25.33 24.67	25	Good

5.4 Geological and Geo-technical Survey

Following study was carried out and in-situ tests on the sub-grade soil of the road have been conducted at intervals of 500 m along the alignments of project roads:

- General Geology of the region, project area and the proposed road corridor were described and geological map of the area has been presented along with major features.
- Nature, type and structure of surface soil were clearly identified.
- Slope stability analysis was properly done and necessary recommendations were provided in this report.
- Natural hazardous area and debris flow area have been identified and necessary recommendations have been provided.
- DCP Test of existing sub-grade at 500 m interval have been carried out to calculate minimum CBR% and following format was used to record and calculate the required data:

  Dynamic Cone Penetration Test (DCP Test)

  Project Name:
  Location:
  Chainage:
  Sample Type:
  Trial Pit No.: Date:

Table: Sample Sheet for DCP Test Data Collection and Calculation

S.N.	No.of Blows (nos.)	Penetration (cm)	Difference (mm)	Cummulative Difference (mm)	DCP (mm/blow)	CBR (%)	Remark
Initial Reading							

Minimum CBR (%):

Dynamic cone Penetration (DCP) test were undertaken in the sub – grade layer to evaluate the In–situ CBR values at 500m intervals.The DCP tests were conducted using hardened steel of 20mm diameter with 60^0 cone angle driven by the impact of a hammer of 8 kg weight with a free fall of 575 mm. the tests were carried out in the sub – grade; recording hammer blows versus penetration to an average depth of 1,000mm or to refusal depth to derive the sub-grade strength. The field data were analyzed and assessed manually using the following TRL Road Note 31 Kleyn and Van Heerden equation to obtain DCP based CBR values.

TRL RN. 31 equation: $\text{Log10 (CBR)} = 2.632 – 1.28 \times \text{Log10 (Strength)}$

Where, Strength = Penetration in mm/blow.

Derived CBR based on above equation is and the results are summarized in Table No. 56

5.4.1 General Geology

Geology is the study of earth and its physical components such as soil, rock, its formation and deformation. Nepal is a mountainous country. Since the Himalayan range is a result of collision of Tibetan and Indian Plates, the zone is the most active tectonic zone. The area is widely known for its complex structural deformations. Due to this, Nepal is suffering from different type of geo hazards and instabilities. The rapid construction of infrastructure such as roads, irrigation canals, and dams, without due relating geology and engineering may cause the failure of such infrastructures. So, there should be consideration of geology of the site in engineering aspect in all stages of investigations and constructions.

5.4.2 Geomorphology

Geologically, the road alignment runs through Lower Tropical and Upper tropical Region.

S.No.	Physiographic Region	Altitude range (m)
1	Terai	Below 300 m.
2	Siwalik	300-700
3	MiddleMountain	700-2000
4	HighMountain	2000-2500
5	High Himalayan	2500-8848

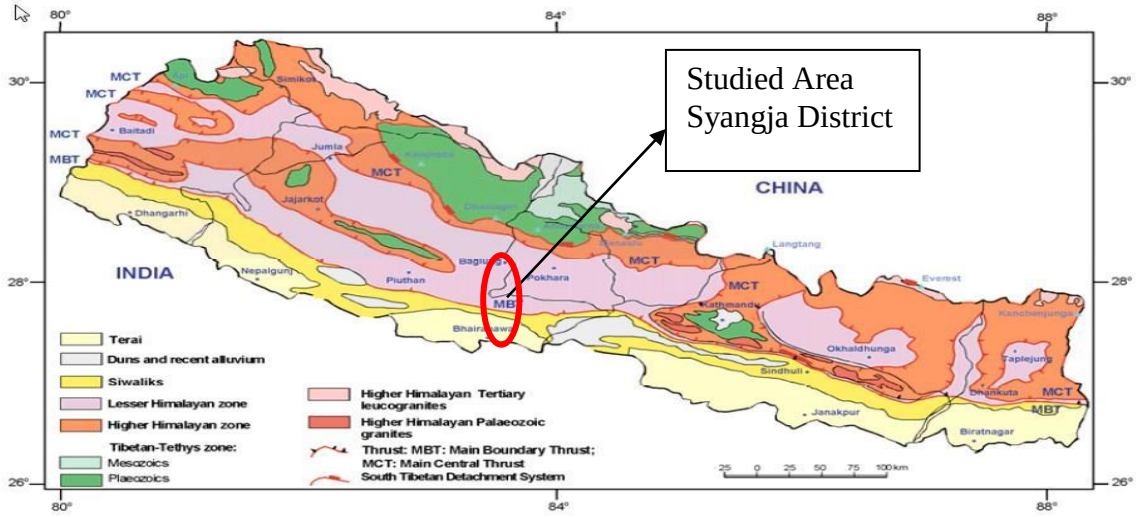


Figure: Geological Map of Nepal Showing Studied Area

5.4.3 Local Geology:

A geological survey has been carried out along 44km (GPS Tracking) alignment of the road sectionKhadketari to Dobilla RoadSection, an important road that connects different VDCs and Municipality of Syangja district as interconnection of Syangja with different Municipality nad VDCs. The road lies in the Western Development Region of Nepal.The proposed road alignment lies inSyangja district, Gandakizone of Western Development Region. The studied alignment starts fromKhadketari of Siddhartha Highway (Chainage Km: 0+000),Latiude: Latitude: 27°30'56.13"N, Longitude: Longitude: 83°36'4.11"E, Altitude: 98.498AMSL of Syangja District and ends atDobillaof Syangja District(Chainage Km: 44+000), Latitude Latitude: 27°27'42.85"N, Longitude: Longitude : 83°13'31.82"E, Altitude: 81.529 m AMSL, Syangja district. The alignment passes through many urban areas, settlement areas, cultivated land, forest area and crosses many major and minor river crossings, plain terrain that lies in Syangja district.

General Chainage wise geology of studied road alignment:

Table General Local Geology

Chainage		Types of Soil
From	To	
0+000	0+500	OS-60BMS-40
0+500	1+050	OS-30BMS-65MR-5
1+050	1+120	BMS-40MR-50HR-10
1+120	1+500	OS-30BMS-60MR-10
1+500	2+000	OS-40BMS-50MR-10
2+000	2+500	OS-40BMS-40MR-15HR-5
2+500	3+500	OS-30BMS-65MR-5
3+500	4+000	OS-30BMS-60MR-5HR-5
4+000	5+000	OS-60BMS-40
5+000	6+700	OS-40BMS-50MR-10
6+700	7+500	OS-70BMS-30
7+500	8+500	OS-40BMS-50MR-10
8+500	10+000	OS-30BMS-65MR-5
10+000	11+000	OS-40BMS-50MR-10
11+000	12+500	OS-40BMS-60

Chainage		Types of Soil
From	To	
12+500	15+000	OS-60BMS-40
15+000	16+500	OS-50BMS-40MR-10
16+500	17+500	OS-40BMS-50MR-5HR-5
17+500	18+500	OS-60BMS-40
18+500	19+000	OS-40BMS-40MR-15HR-5
19+000	19+500	OS-50BMS-40MR-10

5.4.4 Natural hazardous area of the studied road alignment

Table:Natural Hazardous Area of the Studied Road Alignment

SN	Name of River	Chainage	Natural Hazard	Protection Measure
1	Seti Khola	0+300	Erosion	River Training Work
2	Kaule Khola	4+100	Erosion	River Training Work
3	Boski Khola	5+900	Erosion	River Training Work
4	Nanid Khola	11+570	Erosion	River Training Work
5	Tuni Khola	17+520	Erosion	River Training Work
6	Okadi Khola	27+300	Erosion	River Training Work
7	Jare Khola	31+250	Erosion	River Training Work

5.4.5 Geological Hazard Mapping

Description of the hazard of the road alignment

Road alignment is generally in low to medium hazard of the soil and water. The soil and rock hazards are low to medium. The low hazardous soil covers more length comparing with length of the medium hazardous of soil. The main influencing components for occurring of the medium soil hazard are soil depth, land use pattern and the soil slope. Rock hazard in this section is not found. The slope stability of this section is good so necessity for realigning any of the subsection is not envisaged on account of geological consideration. Only problem in this area is water logging and flood in major rivers during monsoon. So, proper channelization of rain water with proper drain should be done and proper river training works should be provided in the major rivers. No realignments of any of the sub section are envisaged on account of geological consideration.

5.4.6 River Crossing Point

S.N	River	Chainage
1	**Kaule Khola**	**4+100**
2	**Boski Khola**	**5+900**
3	**Nanid Khola**	**11+570**
4	Tuni Khola	17+520
5	Okadi Khola	27+300
6	Jare Khola	31+250

5.5 Hydrological and Meteorological Study

Hydrological and meteorological study have been carried out for estimating design flood flows for design of road drainage system and are given below:

- All relevant meteorological (rainfall and temperature) data were collected
- River and its river system are described and catchment area were calculated.
- Collection and review of previous reports and studies were done.
- Desk study on topographical maps and aerial photographs were
- Investigations about flood marks in streams and actual locations of waterways during field visit.

- Identification of erosion prone areas during field visit
- Verification of drainage locations with survey, inventory and field visit data
- Delineation of watershed boundary and determination of drainage area from topographical maps
- Frequency analysis of relevant stream flow data
- Frequency analysis of maximum daily rainfall at relevant stations
- Establishment of IDF (Intensity-Duration-Frequency) curves for different road sections
- Establishment of catchments and channel characteristics (time of concentration and runoff coefficient)
- Estimation of flood flows for adopted return periods by different methods
- Comparison and selection of design discharge for cross and side drains
- Design of cross and side drains.

Hydrology:

General Introduction

Detailed hydrological study at the proposed river crossing has been carried out to find out the hydrological design parameters required for the design of cross drainage structures. The catchment area is estimated from topographical map and ARCGIS 9.3. The high flood discharge was estimated for the return periods of 50 years.

Catchment Characteristics

The coordinate of the outlet point of the catchment in the river crossing is taken from field. The catchment is delineated from ARCGIS 9.3 and the catchment area at the outlet point is estimated. The length of stream from its head to outlet point is determined.

Study Approach

Although the rainfall measuring stations in Nepal are established nearly during sixties the rainfall data is not continuously available. Since short period of the data will not provide the better result for the frequency analysis, which requires minimum 30 years data. Hence, to solve the problem the appropriate rainfall data are collected.

Estimation of peak flow

The high flood discharge is estimated by using different approaches. They are as follows:

Water and Energy Commission Secretariat (WECS) Approach

The Water and Energy Commission Secretariat (WECS) has developed an approach to estimate the flood flows in any un gauged catchment area below 3000 m elevation. The 2 year (Q_2) and 100 year (Q_{100}) return period floods are given by:

Q_2 = 1.8767 x (area below 3000 m + 1) $^{1.183}$

Q_{100} = 14.63 x (area below 3000 m + 1) $^{0.7342}$

The flood for any return period of R years is given by:

$$Q_R = e^{(lnQ_2 + s\sigma)}$$

Where, s = standardized normal variable for a particular return period, R

$$\sigma = \ln\left(\frac{Q_{100}}{Q_2}\right)/2.326$$

Table: Values of S for Different Return Periods

Return period	2 yrs	5 yrs	10 yrs	20 yrs	50 yrs	100 yrs	200 yrs
S	0	0.842	1.202	1.645	2.054	2.326	2.576

Dicken's Method

The flood flows for T years of return period can be estimated by Dicken's method as;

$Q_T = C_T A^{3/4}$

Where, $C_T = 2.342 \log(0.6T)\ log\ (1185/P) + 4$

$P = \left(\frac{a+6}{A+a}\right) * 100$

a = Perpetual snow area in sq. km.

A + a = Total catchment area in sq. km.

Medium Hydro Study Project

The Medium Hydro Study Project (MHSP) under Nepal Electricity Authority (NEA) in 1997 developed a method to predict flood flows at ungauged sites through regional regression technique. The MHSP method has been used to estimate flood flows of 66 hydrometric stations, which were obtained from DHM are used in the regression analysis. The input variables are similar to those used in WECS/DHM method. Regression Coefficients for flood peaks are used for the bridge.

$Q = K A^n$

Table: Regression Coefficients for Different Return

Return Period	K	n
5	6.7962	0.966
20	3.2303	0.9281
50	4.609	0.9071
100	5.9865	0.8888

HFL calculation

Rating curve of the bridge site is developed with the slope area method. The river profile and cross sections of the river are surveyed during the field study. The resulting water level for the flood is computed.

Waterway width

Linear waterway is defined as width of waterway between the extreme edges of water surface at H.F.L. measured at right angles to the axis line. Likewise, effective linear waterway is the total width of the waterway of the bridge at H.F.L. minus effective width of obstruction. This waterway width can be determined by two methods.

Lacey's Formula,

Linear waterway $W = 4.75\sqrt{Q}$

Where, Q = Flood discharge

Kellerhals's Formula,

Linear waterway $W = 3.26\sqrt{Q}$

Where, Q = Flood discharge

In case of hill region, River bed consist of gravel and boulders, thus the waterway adopted by Kellerhal's method and seems to be reasonable in this type of river.

Table :Number of Brigdes

Chainage	Span (M)	Slab Thickness (M)	Depth (M)	Remarks
0+495	30	0.21	4	Existing
18+430	25	0.21	4	Proposed

Side Drain and Cross Drainage Design

The cross-drainages are constructed in the form of Bridges, Culverts, Floodways and Side Drain. The choice of the structures depends on the design discharge, anticipated sediment loads, configuration of flow, foundation condition, ease of construction and cost of structures. Out of the many types of the culverts, the choice depends on the local topography, sediment load, availability of material and costs. Mainly masonry slab culverts, concrete pipe culverts, concrete box culverts and concrete or masonry floodways are considered for the design of the cross drainages.

The hydrological data are obtained from the Hydrology Chapter of this report. The data are precisely derived and the cross drainage structures and side drains are designed based on these data. The hydrology report gives the data of flood estimation derived using the different Method. The road passes through hilly terrain with variations in altitude along the alignment. As the road lies mountain range there is little chance of significant variation in the rain intensity. Therefore, there will hardly be any variation in the rainfall intensity from one place to the other along the road as shown in the hydrology table above. Catchment area is the only variable factor for the calculation of the discharge for each of the streams or watercourses.

As shown in the hydrology report, each natural drain or gully has different catchment area thus having different flood discharges. This will require many sizes of cross drains in the road. It is not practicable to design cross drain for each of these gullies. It is not only practicable but also not economical to provide cross drain of many sizes. Therefore, the discharges from the hydrology report are grouped together. The maximum value of discharge of each group shall be taken for design purpose.

For the seasonal water ways carrying flood water during monsoon season, causeways could be designed as cross drains. Causeways are proposed at the places where the location is appropriate for it and unsuitable for other types of culverts.

Analysis for Maximum 24 hours Rainfall (Gumbel's Type I Extreme Distribution Function)

Table: Maximum 24 hours Rainfall (Gumbel's Type I Extreme Distribution Function)

Analysis for Max 24hr rainfall (Gumbel's Type I Extreme Distribution Function					
S.N.	**Description**	**Symbol**	**Value**	**Unit**	**Remarks**
1	Average	Q_{avg}	139.47	mm	
2	Standard Deviation	s	66.84	-	

Table:Maximum 24 hours Rainfall Data for Various Return Periods (1971-2000)

S.N.	**Return Periods T (Years)**	**Reduce Variate (Y)**	**Maximum 24 hr Rainfall (mm) (R24)**	**Remarks**
1	2	0.367	79.50	
2	5	1.500	86.60	

S.N.	Return Periods T (Years)	Reduce Variate (Y)	Maximum 24 hr Rainfall (mm) (R24)	Remarks
3	10	2.250	104.70	
4	25	2.970	118.20	
5	50	3.902	126.80	
6	100	4.600	132.20	
7	200	5.296	175.50	
8	500	6.214	200.00	

Design of Side Drain and Culverts:

The discharge in a drain is computed from the rational formula

Q = 0.278*C*I*A
Where,
Q = Discharge in m^3/s
C = Run off Coefficient which is taken 0.30 for side drain and 0.40 for pipe culverts.
I = Intensity of Rainfall in mm/hr
A = Catchment area in sq.km.

Run off Coefficient:
Run off Coefficient which is taken 0.30 for side drain and 0.40 for culverts.
Therefore,
Run off Coefficient (C) = 0.30 for side drain
Run off Coefficient (C) = 0.40 for culverts

Intensity of Rainfall:
Intensity of Rainfall is calculated from given table for return period of 10 years.

Table: Maximum 24 hours rainfall data for various return periods

S.N.	Return Periods T (Years)	Reduce Variate (Y)	Maximum 24 hr Rainfall (mm) (R24)	Remarks
1	2	0.367	79.50	
2	5	1.500	86.60	
3	10	2.250	104.70	(Side Drain)
4	25	2.970	118.20	(Cross Drain)
5	50	3.902	126.80	
6	100	4.600	132.20	
7	200	5.296	175.50	
8	500	6.214	200.00	

The rainfall intensity for return period of 10 years is 176.22mm and for 25 years is 189.78mm in 24 hour.
Therefore,
Intensity of rainfall for side drain (I) = 5.45 mm/hr
Intensity of rainfall for side drain (I) = 7.01 mm/hr

Catchment Area:

Catchment Area is taken for side drain as 200m from point of entry to side drain and 500m alongside drain assuming that there is a cross drainage structure at every 500m interval. Similarly, Catchment Area is taken for cross drain as the longest length of stream or watershed is 1.0 km beyond the road with covering distance 100m.

Therefore,

Catchment Area for side drain (A) = 0.08 sq.km.

Catchment Area for cross drains (A) = 0.08 sq.km.

Design Discharge:

Design Discharge for side drain(Q) = 0.278*C*I*A
= 0.278*0.30*5.45*0.08
= 0.0363 m^3/s

Design Discharge for cross drain(Q) = 0.278*C*I*A
= 0.278*0.40*7.01*0.08
= 0.0623 m^3/s

Hydraulic Design of Side Drains and Cross Drains

For the design of the cross drainages over watercourses, and the road side drains, discharge for return period of 25 and 10 years is taken into consideration. The hydrological study has determined the discharges, of 25 and 10 years return period, for all significant watercourses along the road. Other streams or watercourse also need to be bridged to allow the water to flow through even if the discharge is insignificant. The result of the discharges is given in hydrology report. The objective of the hydraulic design is to determine the size of the culvert over the watercourse, so that the estimated discharge flow freely through it.

To determine the size of the pipe, slab or box culverts and the side drains, to allow the design discharge of a stream to flow freely through it, Manning's formula is used. For this purpose allowable discharge capacity of different sized culverts and side drains are determined using the formula.

The Manning's formula is as follows:

$V = 1/n*R^{2/3} *S^{1/2}$

Where,

V = velocity in m/sec

n = coefficient of surface roughness which depends in the roughness of the surfaces. It is generally taken as 0.018 for slab culverts having concrete bottom slab and rubble masonry side walls and it is 0.016 for culverts having all sides of formed concrete. For pipe culverts it could be taken as that for trowel finished concrete which has a value for n as 0.014 and it is 0.017 for random stone masonry in cement mortar.

R = Hydraulic Radius in meters

= Aw/Pw

Aw = Area of flow cross section in m^2

Pw = Wetted Perimeter in m

S = Slope of energy slope of channel, which is roughly taken as slope of culvert bed and drain in %

Finally, the discharge is calculated using the formula,

$Q = V*Aw$

Where

Q = discharge in $m^{3/s}$

For calculating the discharge capacity of the open or covered trapezoidal, rectangular and right triangular or tick drains, same formula as above is applied.

Using the above formula, allowable discharge capacity of the standard sized pipe, slab and box culverts and different section of road side drain with different slopes, are determined and given in tables below. Generally, a free board of 0.6m is provided for the slab and box culverts while determining the discharge capacity. The size of the slab or box culverts and its free board depends in the topography of the stream, design profile of road, expected sedimentation load, debris flow and location of the culverts such as culverts in valleys, mid-hills and the ridges.

The slope of the culvert bed is limited to maximum of 3% because slopes exceeding this value may generate excess velocity of flow to cause erosion at the outlets, requiring additional erosion control measures. For design purpose, the bed slope considered is 3% and resulting allowable discharges are taken for all types of culverts.

However, the road side drain slopes are determined by road profile gradient. Therefore, the drains will have the same slope as the road gradient. The steeper slopes of the drain, causes the water to flow in higher velocity than the shallower slopes. Higher the velocity of the flow higher will be the discharge capacity of the drain and higher the probability of erosion. Therefore, to counter erosion, concrete is recommended as the bedding of side drains.

The capacity of 600mm, 900mm and 1200 mm diameter pipes is calculate using the Manning's formula. For the calculation of the discharge capacity of the pipes, Manning's formula is used. The roughness "n" for concrete pipes is taken as 0.014. The length of the pipe culverts is taken as minimum 12.0 meters and the slope as 3%. The allowable free flow discharge capacity of the three types of pipes culverts are given in table given below.
The maximum allowable discharge of masonry slab culverts and reinforced concrete box culverts of different sizes with bed slope of 3% are given in table given below.

For the design of the road side drains, Manning's formula is used with different longitudinal slopes The discharges for rectangular section of side drains are calculated. The discharge capacities of these sections are calculated for different slopes ranging from below 1% up to 12% depending upon the road gradient. The calculated discharges for different slopes are given in tables for both types of side drains.

Table:Allowable Discharge Capacity of Pipe Culverts

S. N	Description	Dia (d) m	Area (A) m2	Wetted Area (Aw) m	Wetted Perimeter (Pw) m	Hydraulic Radius (R) m	Slope (S)	Roughness Coefficient (n)	Velocity V (m/sec)	Discharge (Q) cum/sec
1	Pipe Culvert	0.9	0.64	0.57	2.83	0.2	0.03	0.014	4.27	2.72

Table: Allowable Discharge Capacity of Trapezoidal Side Drain

S. N	Description	Top Width (w) m	Bottom Width (b) m	Depth (d) m	Wetted Area (Aw)	Wetted Perimeter (Pw)	Hydraulic Radius (R) m	Roughness (n)	Slope %	Velocity (V) m/sec	Discharge (Q) cum/sec
1	Trapezoidal Drain	1	0.775	0.5	0.264	1.428	0.185	0.017	0.01	1.911	0.05
2	Trapezoidal Drain	1	0.775	0.5	0.264	1.428	0.185	0.017	0.02	2.702	0.414
3	Trapezoidal Drain	1	0.775	0.5	0.264	1.428	0.185	0.017	0.03	3.31	0.624
4	Trapezoidal Drain	1	0.775	0.5	0.264	1.428	0.185	0.017	0.04	3.822	0.81
5	Trapezoidal Drain	1	0.775	0.5	0.264	1.428	0.185	0.017	0.05	4.273	0.93
6	Trapezoidal Drain	1	0.775	0.5	0.264	1.428	0.185	0.017	0.06	4.68	1.032
7	Trapezoidal Drain	1	0.775	0.5	0.264	1.428	0.185	0.017	0.075	5.055	1.12
8	Trapezoidal Drain	1	0.775	0.5	0.264	1.428	0.185	0.017	0.08	5.405	1.18
9	Trapezoidal Drain	1	0.775	0.5	0.264	1.428	0.185	0.017	0.09	5.732	1.254
10	Trapezoidal Drain	1	0.775	0.5	0.264	1.428	0.185	0.017	0.1	6.042	1.302

Conclusion for Side Drain

Trapezoidal side drain is proposed in only one side of the road.The size of the drain is proposed to be 0.5*1 to drain out the water from hill side.

Conclusion for Cross Drains

The size of pipe culverts, slab culverts proposed matches with the calculated discharge with adequate free board even in 3% of longitudinal slope as design discharge is calculated as 0.122$m^{3/}$s and maximum capacity of cross drains are more than design discharge.

Meteorology

With variation in altitude, there is also variation in temperature, humidity, precipitation, sunshine hours, wind speed and other climatic factors as well. The meteorological data are computed from New Loc Climate Software with help of GPS co-ordinates taken atSyangja of Syangja district. These data are tabulated in different tables below.

Location: Syangja, Gandaki District
Western Development Region, Nepal

Hydrological and meteorological data (Syangja)

Table No-1: Mean Monthly Temperature

	Best Estimate	Low Estimate	High Estimate	Standard Error	Bias
T_Mean	[°C]	[°C]	[°C]	[°C]	[°C]
January	10.8	7.51	14.09	3.29	0.44
February	12.5	8.98	16.02	3.52	0.3
March	16.8	12.99	20.61	3.81	0.48
April	22.2	18.57	25.83	3.63	0.44
May	24.1	20.52	27.68	3.58	0.13
June	24.6	21.19	28.01	3.41	0.13
July	23.7	20.63	26.77	3.07	0.2
August	23.6	20.56	26.64	3.04	0.28
September	22.7	19.54	25.86	3.16	0.07
October	20.6	17.45	23.75	3.15	0.5
November	15.6	12.5	18.7	3.1	0.54
December	11.8	8.7	14.9	3.1	0.23
Mean	19.08	15.76	22.4	3.32	0.31

Table No-2: Maximum Monthly Temperature

T_Max	[°C]	[°C]	[°C]	[°C]	[°C]
January	17.2	14.26	20.14	2.94	0.66
February	19.2	15.62	22.78	3.58	0.68
March	24.2	20.45	27.95	3.75	0.77
April	29	24.88	33.12	4.12	0.64
May	30	26.03	33.97	3.97	0.51
June	29.2	25.54	32.86	3.66	0.34
July	27.5	24.44	30.56	3.06	0.54
August	27.3	24.31	30.29	2.99	0.59
September	26.7	23.47	29.93	3.23	0.53
October	25.5	22.31	28.69	3.19	0.62
November	22.2	19.14	25.26	3.06	0.82
December	18.7	15.96	21.44	2.74	0.57
Mean	24.73	21.37	28.08	3.36	0.61

Table No-3: Minimum Monthly Temperature

	Best Estimate	Low Estimate	High Estimate	Standard Error	Bias
T_Min	[°C]	[°C]	[°C]	[°C]	[°C]
January	4.4	0.65	8.15	3.75	0.27
February	5.8	2.22	9.38	3.58	0.23
March	9.6	5.51	13.69	4.09	0.17
April	15.3	11.69	18.91	3.61	0.12
May	18.2	14.89	21.51	3.31	-0.18
June	19.8	16.54	23.06	3.26	-0.06
July	20.2	17.04	23.36	3.16	-0.1
August	19.8	16.66	22.94	3.14	-0.11
September	18.7	15.41	21.99	3.29	-0.11
October	15.8	12.65	18.95	3.15	0.34
November	9	5.59	12.41	3.41	0.3
December	4.9	1.23	8.57	3.67	0.02
Mean	13.46	10.01	16.91	3.45	0.08

Table No-2: Mean Monthly Precipitation

	Best Estimate	Low Estimate	High Estimate	Standard Error	Bias
Prec	[mm]	[mm]	[mm]	[mm]	[mm]
January	39	29.46	48.54	9.54	-3.11
February	27	19.06	34.94	7.94	-1.22
March	38	29.08	46.92	8.92	-3
April	47	21.06	72.94	25.94	-1.33
May	90	0	180.04	90.04	-16.44
June	286	162.06	409.94	123.94	-23.22
July	480	286.37	673.63	193.63	-58.67
August	437	258.39	615.61	178.61	-37.33
September	227	134.17	319.83	92.83	-12.67
October	106	69.19	142.81	36.81	-10.33
November	1	0	5.72	4.72	-0.56
December	6	0.76	11.24	5.24	-0.78
Mean	148.67	83.82	213.51	64.85	-14.06

Table No-3: Mean Monthly Evapo-transpiration

	Best Estimate	Low Estimate	High Estimate	Standard Error	Bias
Pet	[mm]	[mm]	[mm]	[mm]	[mm]
January	50.3	39.51	61.09	10.79	1.87
February	61.2	46.04	76.36	15.16	1.43
March	97.9	72.48	123.32	25.42	2.29
April	137.9	108.28	167.52	29.62	2.42
May	152	119.34	184.66	32.66	3.32
June	118.1	90.85	145.35	27.25	0.84
July	110.6	85.21	135.99	25.39	-0.26
August	102.1	79.58	124.62	22.52	1.48
September	90.5	72.1	108.9	18.4	0.33
October	90.4	76.56	104.24	13.84	2.23
November	66.5	57.68	75.32	8.82	2.1
December	51	43.11	58.89	7.89	1.34
Mean	94.04	74.23	113.86	19.81	1.62

Table No-5: Mean Monthly Wind Speed

Wind	Best Estimate	Low Estimate	High Estimate	Standard Error	Bias
	[km/h]	[km/h]	[km/h]	[km/h]	[km/h]
January	3.6	3.12	4.08	0.48	0.24
February	4.32	3.55	5.09	0.77	0.4
March	4.68	4.38	4.98	0.3	0.16
April	6.12	5.44	6.8	0.68	0.36
May	6.12	5.64	6.6	0.48	0.24
June	5.4	4.95	5.85	0.45	0.16
July	4.68	4.12	5.24	0.56	0.24
August	4.32	3.72	4.92	0.6	0.32
September	3.96	3.21	4.71	0.75	0.4
October	3.6	2.83	4.37	0.77	0.4
November	2.88	2.26	3.5	0.62	0.32
December	2.88	2.35	3.41	0.53	0.28
Mean	4.38	3.8	4.96	0.58	0.29

Table No-6: Mean Monthly Sunshine Hours

	Best Estimate	Low Estimate	High Estimate	Standard Error	Bias
Sun Hr.	[%]	[%]	[%]	[%]	[%]
January	60	55.42	64.58	4.58	1.89
February	64	59.35	68.65	4.65	1.44
March	62	57.24	66.76	4.76	1.67
April	61	56.1	65.9	4.9	1.67
May	55	48.1	61.9	6.9	3.11
June	36	29.27	42.73	6.73	0.78
July	37	29.13	44.87	7.87	-0.22
August	35	27.91	42.09	7.09	1.33
September	39	31.47	46.53	7.53	1
October	52	47.28	56.72	4.72	2.11
November	68	63.38	72.62	4.62	1.56
December	66	61.97	70.03	4.03	1.44
Mean	52.92	47.22	58.62	5.7	1.48

Table No-6: Mean Monthly Vapour

Vapor	Best Estimate	Low Estimate	High Estimate	Standard Error	Bias
	[hPa]	[hPa]	[hPa]	[hPa]	[hPa]
January	8.5	6.69	10.31	1.81	-0.16
February	9.1	7.19	11.01	1.91	-0.03
March	10.8	8.36	13.24	2.44	0.32
April	12.1	9.39	14.81	2.71	0.28
May	15.4	12.09	18.71	3.31	-0.1
June	23	19.23	26.77	3.77	0.14
July	25.5	22.07	28.93	3.43	0.24
August	25.2	21.6	28.8	3.6	0.08
September	23.7	20.08	27.32	3.62	0.23
October	16.1	12.45	19.75	3.65	-0.14
November	11.2	8.71	13.69	2.49	0.13
December	8.7	6.61	10.79	2.09	-0.03
Mean	15.78	12.87	18.68	2.9	0.08

CHAPTER 6: DESIGN AND DRAWINGS

The design standard adopted for the detailed design followed the "Design Standards for Highway of "Nepal Road Standard (2027), Second Revision 2070", based on traffic volume and possible network importance. Geometric parameters followed are described below:

6.1 Geometric Design Standard

The design of the proposed road has been done as per Nepal Road Standard 2070

Design Parameters:

Table: Geometric Design Standard

S.N.	Design Parameters	Adopted Value (As per NRS 2070)
1	Design Speed	40 km/hr
2	Right of Way both side from road centre line	15 m
3	Formation width	8.5 m (without Drain)
4	Carriageway width	7m (5.5 m Black top)
5	Shoulder width	0.75 m (Both Side)
6	Camber of Carriageway % Service Road	2.5%
7	Camber of Shoulder	4%
8	Minimum radius in horizontal curve	15 m (12.5m exceptional)
9	Minimum radius in vertical curve	0 m
10	Minimum length	40 m
11	Maximum gradient	10%
12	exceptional gradient	12 Or 11.5m
13	Average gradient	7%
14	Minimum over taking distance	165m
15	Minimum Stopping Sight Distance	50 m
16	Maximum Super Elevation (%)	10 %

Cross-Section:

1.	Right of Way:	30m (15 m on either side of theroad)
2.	Formation Width	: 8.5 m (without Drain)
3.	Carriage Way Width	: 7m (5.5 m Black top)
4.	Shoulder Width	: 0.75 m (Both Side)
5.	Side Drain	: Semi-Trapezoidal Shape
6.	Camber	: 2.5%

Pavement:

Sub-Base	(1) Materials: Gravel Coarse (2) Thickness: 200mm
Base	(1) Materials: Crushed Stone (2) Thickness: 200mm
Surface	Type: DBSD

6.2 Design Speed

When the design speed is higher, the design standards should be of higher order which ensures the road safety, capacity, comfort and decreases the users' operational expenditure. The choice of design speed, however, would be influenced by the class of road, traffic volume, available budget and the terrain. The design speed adopted for the proposed road is 40 kmph.

6.3 Right of Way

As per the Nepal Road Standard, right of way adopted for the proposed road is 15 on either side from the road center line.

6.4 Formation Width

Formation width of the adopted for the Existing road is 8.5 m (without Drain) m.Shoulder width of 0.75m on either side camber slope of 2.5%.

6.5 Extra Widening

Extra widening has been proposed at curves. Following table shows the nature of extra widening adopted for the designing of the proposed road.

6.6 Sight Distance

Sight distance is the length of road ahead visible to the driver. This distance should be long enough for the driver to see a situation and successfully react to it. The stopping sight distance considered for the design of the proposed road is taken as 30m.

6.7 Horizontal Curves

The horizontal alignment of a highway consists of a number of straight (tangent) sections connected by horizontal curves. These curves are sections of a circle or spiral. Curves should be designed to minimize vehicles skidding off the travelled way (excessive vehicle yaw) or overturning (excessive vehicle roll). As per the Nepal Road Standard, the minimum radius of horizontal curve is taken as 15m.

6.8 Vertical Curves

Vertical curves provide for a gradual change in grade between the approach tangents. Vertical curves should be designed to provide sufficient sight distance, comfortable operation, efficient drainage, and a pleasant appearance. Long vertical curves generally have a more pleasing appearance than short vertical curves.

6.9 Longitudinal Section

Longitudinal section shows the existing profile of the proposed road. The longitudinal section of the road was taken at 20m intervals by driving wooden pegs. The center line survey of the road was carried out at each chainage point by auto level. Any sudden change in the gradient was also recorded. A general minimum gradient of 1% was adopted in very flat conditions. Maximum recommended grade of 10% as per the Nepal Road Standard was adopted.

6.10 Cross Section

The cross section survey was conducted at every chainage point to obtain the existing ground condition. Other necessary details were also taken during the cross section survey. The cross section survey was conducted to a minimum of 25m on either side of the proposed center line of the road. However, at places requiring further details the survey was extended beyond 15m to cover the features.

6.11 Passing Bays

The passing bay of 20 meter length and 3.5 meter width has been proposed. The passing bay has been proposed in such a way that no additional retaining structures is required.

6.12 Retaining Structures

Retaining walls are structures to support backfill and surcharge load from the fill section of the road. Normally, they are constructed on the valley side of the road. Retaining structures are not intended to stabilize the slope failure but are meant to support active or passive earth pressure from the assumed failure wedge above the base of the wall. Retaining structures are constructed for the following purposes:

- To minimize the volume of excavation and to achieve cut and fill balanced sections
- To support the road completely or partially in fill
- To stabilize fill slopes and cut slopes
- To support the toe of a weak slope
- To prevent erosion on steep sloping cut faces as revetments.

6.13 Dry Stone Masonry Wall

Dry stone masonry walls are the most economic earth retaining structures. For effective functioning, the height of the retaining wall should be limited to 3.5m. However, the same is not recommended where there is scope for continuous flow of water, such as where causeways are proposed art river/stream banks.

The backfill on the rear side of a dry masonry wall needs to be of selected material that is pervious nature. Appropriate compaction in layers is essential to backfill the material effectively. Dry stone walls are favoured under the following conditions:

- Availability of sound stones in proximity of the site.
- Foundation conditions are uniform and geo-technically favourable i.e. fairly dry and stable slopes, low earth pressure.
- Availability of pervious backfill and low seepage pressure.
- Dry masonry walls should not be used in drainage outlets, high water flow, moist areas and areas with high ground water.

6.14 Gabion Masonry Wall

One of the most important advantages of gabion structures is that they act in a homogeneous way and possess high flexibility. Gabion structures are capable of deforming without loss in structural strength, and are able to accommodate settlement without rupture. They are highly permeable and allow free drainage through the wall. The gabion structures are favoured under the following conditions.

- As a retaining and support structures in weak foundation conditions, wet soils, high ground water, high seepage pressure areas etc.
- To retain the road completely or partially in fill when the height of fill exceeds 3.5m.

- To strengthen and regulate natural slope drainage systems and water flow areas as protection works around drainage outlets.
- Protection to unstable slopes, such as slope movement due to creep, landslides, etc.
  The general principles adopted in design and constructions are:
- All wires used in gabion boxes should have a heavy galvanized zinc coating.
- To achieve monolithic design and strength, all gabions should be firmly wired together with continuous lacing at the edges, with double loops at each binding place. This is done mostly before filling.
- Erection of gabion walls should start only after inspection and acceptance of the foundation. Permanent dampness must be avoided during the construction period, as well as thereafter.
- The use of large size, hammer dressed, tabular stones, staggered joints, proper bonding and interlocking between the stones must be ensured.
- During the filling of the stones, bracing wires should be fixed at one third and two thirds height inside the boxes.
- The rear of gabions should be provided with a filter bed with well compacted smaller stones to facilitate water flow.
- When gabion structures are used in wet and weak soil, the rear face should be curtailed with geo-textile fabric to retain the fine particles, allowing the water to percolate.

6.15 Water Management Measures

Conservation of natural drainage patterns along the road alignment is one of the major considerations that should be made during the design and construction of drainage structures. Water accumulated and concentrated on the road surface is a major threat to earth roads as it causes rutting and formation of gullies and rills. A fundamental technique applied in water management is to ensure that the rain water is evenly distributed off the road surface, towards the valley side. This is achieved by providing the road surface with an outward cross slope, thereby preventing the rain water from accumulating on the road surface.

6.16 Outward Cross Slope

The road surface is generally provided with 4% outward cross slope to allow the surface run off to disperse gently on to the hill slope along the complete length of the road, thereby reducing the possibility of erosion. Displacement of water by the outward cross slope also eliminates the problem of discharging water collected from the drains in larger volumes. Care should be taken to prevent water from discharging over fill slopes. In the interests of safety, special considerations need to be adopted along slippery areas (red soil), where the road amber needs to be sloped inwards (hill side) with provision for drainage. Construction of low bund with local material enhances the driver's confidence when the surface is wet. Ideally it is preferred if such slippery areas are gravelled.

6.17 Side Drains

At locations where the road profile gradient is greater than 5%, rain water may flow longitudinally along the road, scouring weak surfaces and forming a gully along the road. In such cases, drains are provided to guide the rain water to the nearest cross drainage structure or gully. Outlets to side drains are designed in such a manner that scouring by the water flow is prevented. Generally, rectangular drain and trapezoidal drain will be used for design.

6.18 Cross Drains

The cross drainage structures proposed for the construction on urban roads are RCC causeways, vented concrete causeways, box and slab culverts, irrigation water crossings and pipe culverts. Selection of the type of cross drainage structures depends on the flow characteristics (discharge, sediment load etc.), local topography, access to the site and availability of materials.

6.19 Sub-Surface Drains

Hillside slopes with excessive water seepage are provided with sub-surface drains along the hillside of the road. The sub-surface drain (50cm X 50cm) consists of filter material (40mm single size aggregate) enclosed by geo-textile fabric. The water from the sub-surface drain is discharged at intervals of 30m along the length of the road.

6.20 Structure

The selection of one or the other types of structures is a subjective matter and reference has been made to the type of cross-section, hazard level, soil characteristics and many other parameters. Historical data were used widely rather than going into detailed quantity measurement. It is assumed that for this level of study, exact quantity calculation is neither necessary nor relevant. The cross-drainage, however, has been considered when the proposed alignment passes through the natural depression (e.g., river, stream, gully, etc.). The cross-drainage structures like culvert and bridge are classified as following. This classification is merely based on the recommendation of NRS 2045.

Culverts: up to 6m span (Slab, Box, and Pipe)
Minor bridge: up to 20m span
Medium bridges: about 20m length, span<20m
Major bridges: Span>20m

In addition, pipe drains at frequent intervals depending upon the extent of catchment uphill have been proposed to let the surface run off downhill. In all cross-drainages, the width of road is kept equal to the carriageway width plus shoulders. The loading standard to be adopted for the design of bridges and culverts will be IRC class AA and A.

6.21 Pavement

The pavement at the proposed road will be of DBSD except in causeways. The pavement shall be the wearing layer of bitumen. The gravel mixed with required quantity of binder (e.g. sand, clay, etc) is compacted over the rammed earth in layers to get a rolled thickness of 200 mm. In very weak sections, greater thickness has to be provided likewise. The gravel layer has to be compacted to a minimum 98% of maximum dry density obtained by standard proctor test at optimum moisture content.

6.22 Engineering Drawings

The designing work was carried out in SW Roads and Smart Road Software. After the completion of the designing works, the drawings were exported in AutoCAD. Drawings were prepared according to norms provided in terms of reference and submitted in separate volume i.e. Volume II.

CHAPTER 7: ENVIRONMENT STUDY

7.1 General

This study aims to identify the major environmental impacts that will be caused by the proposed road project. Being a concise study, the TOR has not been prepared and the issues in this study are based on the direct field visit.

Scope of the work related to the IEE/EIA study

The IEE will be conducted to ensure the environmental sustainability of the project, to integrate mitigation measure for environmental impact into the project preparation process, and provide plan for environmental management during project implementation. The GON requires all projects to undergo environmental assessment. All projects must comply with Environmental Act and Regulation to ensure that projects are environmentally sound, are designed to operate in compliance with applicable regulatory requirements, and are not likely to cause significant environmental, health, or safety hazards. On the GON side, the statutory requirement that has to be adhered is the Environment Protection Act (1997), and Environment Protection Rules (1997 and as amended in 1999 and 2007). Based on EPR Schedule 1, the Subproject is within the threshold of activities under the road sector that will require IEE.

This IEE fulfils the policy requirements of the GON. The IEE Report primarily:

- Provides information on the project and its environmental requirements;
- Provides the necessary baseline conditions of the physical, ecological, physical cultural and socio-economic environments and/or resources in and surrounding the Subproject's area of influence;
- Identifies and assesses potential impacts arising from the implementation of the Subproject on these environments and/or resources;
- Recommends measures to avoid, mitigate, and compensate for the adverse impacts;
- Presents information on stakeholder consultations and participation during Subproject preparation
- Recommends a mechanism to address grievances on the environmental performance of the Subproject; and
- Provides an environmental management plan. Relevant reports/Documents, sites reconnaissance, consultations with communities and relevant government agencies and reference to relevant government policies, laws and regulations have provided bases to this IEE.

The scope of the work is to produce an account of the initial environmental examination (IEE) of the proposed road projects. The main aim of IEE study is to follow Rule 7 and Annex 5 of EPR, 2054 (1997) including its amendment, 2055. The National Environmental Impact Assessment Guidelines, 1993 and the spirit of EPA, 2054, will guide the norms for this study. The general scope of this IEE would be:

- To identify and analyze the potential environmental impacts (whether positive or adverse) on physical, biological, socio-economic & cultural resources, from the location, design & construction of project structures & associated facilities in tile project areas.

- To propose the suitable mitigation measures for minimizing the potential negative environmental impacts and to augment the positive ones to improve overall performance of the project
- To define and prepare appropriate environmental monitoring and management plan.
- To determine the potentials for the improvements to natural resources and environmental management and socio-economic benefits to the communities in the project areas and its surroundings.
- To receive public feedback for safeguarding the natural environment with least negative impact on its natural settings and also to adequately assess & document community requirements relating socio-economic & cultural aspects in the project areas.

To prepare IEE report as per the requirement set forth by Environment Protection Act (1997), and Environment Protection Rules (1997 and as amended in 1999 and 2007).

7.2 Field visit by Environmentalist

A walkover survey along the proposed route was carried out during June-August 2016 to gather information on the physical, biological and socio-economic and cultural environment of the project area. The impacts of the activities on physical, biological, socio-economic and cultural resources in the defined influence area were analyzed.

7.3 Public participation in the field

During this study, different groups of people were interacted. During the public interaction the proposed alignment of the road to be upgraded and the specific environmental issues that may arise due to the implementation of proposed project were shared and discussed.

7.4 Identification of Benefits and Impacts due to Proposed Road Related Activity

Identification and prediction of benefits and impacts have been made by the study team giving due consideration to the proposed actions/activities during upgrading and operation stages. Both beneficial and adverse impacts have been analyzed.

The potential impacts have been predicted in terms of their magnitude of significance (minor, moderate and high), extent (site specific, local and regional) and duration (short term, medium term and long term) as well as their nature (reversible and irreversible).

7.4.1 Beneficial Issues:

I) Upgrading Phase:

Employment opportunities

The first and foremost benefit that people may accrue in the upgrading works is employment. During the upgrading of the existing road, temporary employment opportunities for unskilled and semiskilled labors will be generated. The impact is thus *direct, medium significance, local* but *short-term* in nature.

Increase in economic activities

During construction period, different types of economic activities will come into operation in order to meet the demand of construction crew. The demand of products such as pulses, milk, meat, vegetables, fruits etc. will rise during the construction period which may provide added impetus for market economy. Such activities will contribute to local economy. This impact will be *direct, minor significance, local* and *short-term* in nature.

Skill enhancement

This strategy for providing jobs not only provides employment opportunities to the poor but also supports in transfer of skills and technical know- how while working in similar construction works. The employment opportunity will, on the other hand, be able to develop project type specific skill among the workers which could subsequently be used in other project. The impact is *indirect, medium significance, local and long-term* in nature.

Gender issues (Women Empowerment)

Women will be encouraged by the proponent and the contractor in the construction work. Women will not be discriminated in wages and remuneration. Hence, this will contribute to women development. The impact is *indirect, high significance, regional* and *long term* in nature.

II) Operation Stage:

Improved access and reduced travel costs

The upgrading of road will offer easy, comfortable and quick access to the people to markets, social services and other parts of the city areas. This will be *direct, high significance, regional* and *long term* impact.

Enterprise and commercialization

Currently more time has been consumed for local people to sell their products in the city areas. But during operation phase of the project, commercial activities such as supply of vegetables, pulses, milk, meat and fruits etc will be quick and farmers will get motivated for the selling of their products and therefore this will provide added impetus for market economy. This will contribute to the local economy and may help enhance the business. This impact will be *direct, medium significance, regional* and *long term* impact. The project affected areas are considered as pocket areas for poultry farming, milk and vegetable production.

Environmental cleanliness

Upgrading the road to Bitumen will reduce the re-suspension of dust in the environment. The improved condition of road will emit comparatively low particles matters which enhance the air quality. The increased efficiency of the vehicles will result in less carbon production and hence healthier environment. This may also help the country in carbon-trade and eventually affect the economy of the country. The aesthetic value of the temples and surrounding milieu will be enhanced. This will be *direct-indirect, high significance, local to regional* and *long term* impact.

Tourism

Improved road access will enhance the tourism in the area. The upgrading of the link road may increase the accessibility to the tourist hotels. The beautiful and scenic areas can also be reached from this link road. The undiscovered areas that may have tourism significance may be discovered and it may help to raise the local economy. Therefore, this will have *direct, high significance, regional* and *long-term* impact on the areas.

Enhancement of social services

Improved road access will enhance the quality of socio-economic health, communication, market and banking. Qualified technicians and other service providers will be encouraged to stay in the area. This will have *indirect, high significance, local* and *long-term* impact on the area.

Rise of land values
Road upgrading often leads to rising land and houses values along the road corridor which further increase the revenue collection. Increased land and houses values also enhance local's capability for borrowing loans through collateral. High value lands are easily acceptable to banks and micro-finance institutions to provide loans. This impact will be an *indirect, medium significance, site specific* and *long term* in nature.

Waste generation/management
Haphazard waste disposals on the road side are an environmental issue in the project area. During the operation stage these problems will be discouraged by greenery maintenance. The road-side dustbins will be very effective to maintain the environmental cleanliness and to exemplify the waste management. Thus the impact is *indirect, medium significance, local* and *long term* in nature.

Stability of road corridor
Bioengineering and additional plantation adds to the stability of the road corridor. After maturity of the recommended plant species, it would also enhance greenery and improves quality of air and view of the road corridor. Thus the impact is *direct, local, medium significance*and *long term* in nature.

7.4.2 Adverse Impacts:

7.4.2.1 Adverse Impacts on the Socio-economic and Cultural Environment

I) Adverse Impacts: Construction Stage

Loss of community infrastructure
Electric poles will have to be shifted for the improvement of existing road network. The community drainage should have to be relocated from the current positions in many areas. Similarly "Chautaro" and resting sheds have to be relocated during upgrading of the existing road (Table 8.2). The relocation cost therefore should be incorporated in the estimate for mitigation measures. The impacts will be *direct, medium significance on community level, site-specific* and *short term to medium term* in nature.

Occupational health and safety
During construction phase, the work personnel will be exposed to various health risks and hazards. The hazards will be notable due to injuries to workers while working in the project if adequate safety measures and equipments are not adopted. Other potential impacts to health are Respiratory and eye disease due to exposure to dust and smoke. Unsafe water sources and unhygienic conditions bear the risk of additional epidemic diseases, such as dysentery, diarrahoea and cholera. These effects are *indirect, minor significance, site specific* and *short term* in nature.

Sanitation issues
Improper sanitary practices of workers such as open urination or defecation can cause sanitary problems in construction sites. These are *direct, minor significance, site specific* and *short term* in nature.

Social conflicts, crime and social security

The extra influx of the workers may cause change in social structure and may increase the crime and security problems. These impacts leading possibility to social and cultural conflicts will be *indirect, low significance, local and short-term* in nature.

Settlement issues

As the upgrading work includes the DBSD of the existing gravelled and earthen section of the road, extra widening of road is required during the upgrading works. Hence there can be issues related to resettlements. The upgrading work may disturb the ethnic people living along the road alignment. These impacts are *direct, high significance, local level* and *medium term* in nature.

Impacts on cultural, religious and aesthetic sites

Acquisition of cultural or religious or aesthetic site is not likely to occur during the upgrading activities. If incurred, the problem of sound and air pollution may occur in these areas. These impacts are *direct, low significance, site specific* and *short term* in nature.

II)Adverse Impacts: Operation Stage

Population pressure and impact on the road alignment

The establishment of settlements, shops and food stalls along the road-side soon after improvements of road is common feature in Nepal. The existing trend is to settle along the road for economic opportunities. Apart from conventional convenience, increases in land value on adjoining road and land speculation are important drivers for such undesired and uncontrolled development. Negative consequences of settlements are: road blockage, delays in private and public transports, increases of local accidents, deforestation, increases in carbon production, undesired landscape destruction and reduction of the overall road capacity. This can cause *indirect, local level,significant* and *long-term* adverse impacts if such activities are not controlled in time by enforcing strict legal actions and social pressure.

Conflict and social structure

There are a number of road-induced impacts that have the potential to exert pressure on the local communities and cause potential social conflicts. People/businessmen from other places may displace the locals and persons that are currently living at the area since they will not cope with increased rent value. Such impacts may lead to social conflict of varying severity. The likely impacts may be *indirect, of low significance, local* and*medium-term* in nature.

Road accidents

Operation of the proposed road also increases chances of road accident. Inadequate provisions of road safety measures like road signals, lack of enforcement of traffic rules during operation period may invite accidents. The anticipated impacts will be *direct, medium significance, local and long term* in nature.

Migration and ribbon development

After the development of easy access road people from remote areas and some people from cities may also migrate for various purposes like business etc. Similarly some places are already as ribbon settlements; the implementation of the proposal may enhance the formation of ribbon settlements in other places too. The anticipated impacts will be *direct, of medium significance, local and long term* in nature.

7.4.2.2Adverse Impacts on the Biological Environment

I)Adverse Impacts: Construction Stage

Impact on natural floral status due to tree felling

A number of trees have to be cut during upgrading of the existing road. The most common types of trees found in these areas are Saal, Sanjh, Sisau, Salla, Simal, etc. the trees should be cut during upgrading stage in direct co-ordination with the District Forest Office of the respective districts. Due to tree felling the small trees may get destroyed and the soil also becomes unstable. If the trees are cut in large number, there will be impact on the precipitation pattern also. Thus, the impacts will be *direct/indirect, of medium significance, local level and long term in nature.*

Impacts on natural habitats

The types of natural fauna found in the impact area of these roads are Tiger, Elephant, Deer, Bear, Fox, Ghoral, Kalij, Bhyakur, Jureli, Luinche, etc. Due to cutting of trees and other construction works, there will be disturbance in the natural habitat of these species in varying extent from place to place. The expansion (excavation, filling, tree falling, machinery operation, etc.) may directly hamper the settlement of some animals and birds. Thus the impact will be *direct, of low significance, local level and short term in nature*.

Impact on aquatic biodiversity

The upgrading work might pollute the nearby river systems. For example there is need to construct bridge at various rivers, so while upgrading the road in that area and during construction of bridge, the sediment and the chemicals may pollute the water in the rivers/streams, which may hamper the aquatic life like fish, turtle, snakes, etc. significantly. So, they should be controlled to avoid water pollution. The anticipated impacts will be *direct, medium significance, locally confined and short-term.*

II) Adverse Impacts: Operation Stage

Wildlife disturbance

The operation of the road will have some impact to the biological environment. The noise created due to traffic in the upgraded road may disturb some of the bird and wildlife species. Also, the high speed of the vehicles may kill some species if they are found resting/sleeping on the road/roadside. The impacts may be expected as *direct, low significance, local level and long term.*

7.4.2.3 Adverse Impacts on the Physical Environment

I) Adverse Impacts: Construction Stage

Impacts on air, noise and water pollution

At the construction phase, there are likely chances of emission of dusts and smoke. This will be temporarily, intense along the construction sites. Dust will also affect the road side vegetation and structures. The impact due to air pollution will be *direct, of medium significance, site-specific* and *short term* in nature. During construction, the construction

activities and movement of vehicles will slightly increase noise level due to the nature of work. This will be *direct, low significance, site-specific to local* and *short term* in nature.

Disturbances on landscape and existing settlement

The excavation, filling and cutting will occur during the upgrading of the road. The width of the road is already maintained in most of the places but in some places it requires cutting and filing.Few land or settlement is required for the upgrading work.

Erosion

Being an existing earthen road, the construction work will not require major earthworks. However, some sections will require widening of the road section and clearance for ROW. Moreover, being in hill slopes, the small excavation may cause instability to the existing naturally stable soil. Hence, erosion will be significant. These impacts will be *indirect, highly significant, local level* and *long term* in nature.

Chemical impacts

The construction work itself and unawareness of the worker may pollute the air as well as river during the construction and improper waste disposal should be discouraged in the construction phase. These impacts are *direct, medium significant, local level* and *short term* in nature.

Cross drainage

There are some drainages passing to agricultural land. These drainages should be maintained as the local people are depended to irrigate their agricultural land through these drainages. The upgrading work will create *direct, highly significant, site-specific to local* and *long term* impact on existing drainage system in the area.

II) Adverse Impacts: Operation Stage

Air and noise pollution

Operation of vehicles in roads in the operation phase can cause air and noise pollution. As the density of vehicles in the road is expected to be comparatively high, the impact due to noise and air pollution from vehicles will be high and will become nuisance to sensitive spots like schools areas, residential areas and the temple areas. The impacts will be *direct, of low to medium significance, site-specific* and *long-term* in nature.

.5 Site Clearance:

Clearing of grass, removing roots breaking sods, levelling the surface and disposal to 10m.

7.6Construction Materials Spoil Management:

This Spoil Management forms part of the Construction Environmental Management Plan (CEMP).

The purpose of the SMP is to:

- Identify the environmental management issues associated with the sourcing, handling, transportation, stockpiling, disposal and reuse of spoil material; and
- Document and describe the systems and procedures developed to mitigate environmental impacts.

The objectives of the Spoil Management Sub Plan are to:

- Manage spoil generated during the Project in accordance with preferred waste management hierarchy of avoidance, minimisation, reuse, recycling and finally disposal;
- Where possible ensure all clean and/or treated spoil shall be reused or recycled;
- Minimise off-site disposal of spoil;
- Minimise the impact of erosion and sedimentation from construction activities associated with the Project;
- Provide an organised, integrated and systematic approach to effectively address spoil management issues during the project; and
- provide staff with an increased level of understanding and awareness of spoil and fill management issues.

Table: Summary of Impacts on Environment and their Level

Type of impacts	Project phase	Impacts	Way of impact	Level of significance	Extent of impact	Duration of impact
Beneficial	Upgrading	Employment opportunities	Direct	Medium	Local	Short term
		Increase in economic activities	Direct	Low	Local	Short term
		Skill enhancement	Indirect	Medium	Local	Long term
		Gender issues (Women Empowerment)	Indirect	High	Regional	Long term
	Operation	Improved access and reduced travel costs	Direct	High	Regional	Long term
		Enterprise and commercialization	Direct	Medium	Regional	Long term
		Environmental cleanliness	direct-indirect	High	Local to regional	Long term
		Tourism	Direct	High	Regional	Long term
		Enhancement of social services	Indirect	High	Local	Long term
		Rise of land values	Indirect	Medium	Site specific	Long term
		Waste generation/management	Indirect	Medium	Local	Long term
		Stability of road corridor	Direct	Medium	Local	Long term
Adverse (on socio-economical and cultural environment)	Upgrading	Loss of community infrastructure	Direct	Medium	Sitespecific	Short term to medium term
		Occupational health and safety	Indirect	Minor	Site specific	Short term
		Sanitation issues	Direct	Minor	Site specific	Short term
		Social conflicts, crime and social security	Indirect	Low	Local	Short term
		Resettlement	Direct	High	Local	Medium term

Type of impacts	Project phase	Impacts	Way of impact	Level of significance	Extent of impact	Duration of impact
		Impacts on cultural, religious and aesthetic sites	Direct	Low	Site specific	Short term
	Operational	Population pressure and impact on the road alignment	Indirect	Medium	Local	Long term
		Conflict and social structure	Indirect	Low	Local	Mediumterm
		Road accidents	Direct	Medium	Local	Long term
		Migration and ribbon development	Direct	Medium	Local	Long term
Adverse (on biological environment)	upgrading	Impact on natural floral status due to tree felling	Direct/indirect	Medium	Local	Long term
		Impacts on natural habitats	Direct	Low	Local	Short term
		Impact on aquatic biodiversity	Direct	Medium	Local	Short term
	Operation	Wildlife disturbance	Direct	Low	Local	Long term
Adverse (on the Physical Environment)	Upgrading	Impacts on air, noise and water pollution	Direct	Low	Site specific to local	Short term
		Disturbances on landscape and existing settlement	Direct	Low	Site specific	Short term

Type of impacts	Project phase	Impacts	Way of impact	Level of significance	Extent of impact	Duration of impact
		Erosion	Indirect	High	Local	Long term
		Chemical impacts	Direct	Medium	Local	Short term
		Cross drainage	Direct	High	Site-specific to local	Long term
	operation	Air and noise pollution	Direct	Low to medium	Site-specific	Long term

7.5 Environmental Management Action Plan

Identification and prediction of impacts of the access road upgrading (Bituminous) works on local environmental safeguard and environmental management action plan has been incorporated into this concise IEE report as it is key safeguarding tools against adverse impacts. Environmental management action plan foresees and delineates key environmental impacts likely to arise with the undertaking of access road upgrading and proposes practical safeguards (including mitigation) along with it implementation responsibilities of road builders associated with the undertaking of activities of access road widening, its supervision, monitoring and reporting and corrective measures, improvement proposals and the cost estimate for undertaking safeguards.

The local geology and its interaction with climate largely determine the nature and type of soil that occurs at ground surface. The geological characteristics of principal importance in this respect include the mineralogical composition of the bedrock, which determines its chemical stability under different climatic regimes. The texture and fabric on the way in which the minerals are distributed and interrelated is important in determining the porosity of the intact rock and the ability of agents to initiate alteration. The structure of the rock mass, such as the distribution of discontinuities; bedding planes, joints and faults determines the ease by which weathering agents can gain access to the rock mass to initiate the weathering process. Therefore, protection and stabilization measures have to be designed as per topographical, geological and hydrological situation. Protection works are applied for landslide with shallow depth about 0.5m, where as stabilization method will have to be applied for deeper slide.

7.5.1 Slope Protection Measures

Cut slope and fill slope should be identified before design of protection measures. Identification of protection system largely depends upon earthwork in excavation in different soil and rock types. Stone pitching, bioengineering methods jute -matting on the cut slope, grass seeding over the fill slope can be applied to stop soil erosion for shallow slip. Since bio-engineering approach found to be successful in many of the road project in Nepal, bio-engineering and bio-technical engineering methodology has been discussed below. Bio-engineering is the application of vegetation and vegetation structure to replace minor engineering structure meant for soil stabilization and slope protection work. Bio-engineering replaces conventional retaining structure like retaining wall, chutes etc. with carefully engineering combination of natural vegetation. Therefore it is very cheap both tomake and maintain, not much skill is required; hence local labors can be used to construct and maintain these structures. It encourage to grow vegetation in the excavation slope and embankment slopes thereby adding to the most important aspect achieved by the bio engineering measure in the road construction. Implementation aspects of bio-engineering application must be carefully studied and worked out during various phase of the road design and construction.

Natural hazards observed and their protection measures at different location are tabulated below:

Table: Major Natural Hazardous Area and Protection Measures

SN	Name of River	Natural Hazard	Protection Measure
1	Seti Khola	Erosion	River Training Work
2	Kaule Khola	Erosion	River Training Work
3	Boski Khola	Erosion	River Training Work
4	Nanid Khola	Erosion	River Training Work
5	Tuni Khola	Erosion	River Training Work
6	Okadi Khola	Erosion	River Training Work
7	Jare Khola	Erosion	River Training Work

7.5.2 Erosion Control:

The control of soil erosion during and after construction is one of the most important roadside problems. In the first place, badly eroded slopes and ditches are unsightly. Then the materials that are washed away by muddy and polluted streams disrupt drainage by filling ditches and culverts. It follows that modern design must not permit erosion to occur.Wind erosion is most effective where the ground surface is generally smooth and free of vegetative cover, the area is reasonably exposed and extensive and the soil is loose, dry and finely divided. The erosion by wind and water can be controlled by ground cover which is defined as low growing herbaceous or woody plants not more than one meter high at maturity, establish and maintain organic residue, roughen the land surface. Both low shrubs and vines are included. It also serves as insulation that reduces sloughing caused by freezing and thawing.

The project site is located in hilly area of the country. The erosion problems would be highly identified in the cutting sections of the proposed road. Most of erosion problems are encountered during monsoon. The most common measures to be adopted for the erosion control are:

- Check Dams
- Making gentle to the cut slopes
- Making awareness to the local people about erosion.

Gabion walls are used in many sections of the alternatives. Road way should be protected against erosion by providing side drains with stone lining. Depending upon the hazard analysis the specific sections were treated for the erosion control measure.

7.5.3 Soil Conservation Measures:

Soil with the potential to nurture crops is an invaluable resource that results from nature's efforts over tens or hundreds of thousands of years. Human efforts can destroy this resource in only a few years. Soils are formed from the interactions of five series of factors: parent material, climate, organisms, topography and time. The soils of Nepal tend to be dominated by the effect of the extreme topography of the mountains. Some soil has been further developed by terracing, whether for dry farming or paddy farming.

7.5.4 River Training Works:

River training works should be done for various purposes such as protecting land and settlement adjacent to the river bank against erosion, diverting the flood water away from the bank, hecking the river from spilling flood water into the village. Several types of river training are in use. Revetments are provided to protect the bank from erosion. Material like loose stones, bricks, stones filled in gabions, sand filled in bags are used for such works. Similarly small spurs, usually called studs, are provided to keep the flood water away from the bank. Long spurs are provided to direct the course of the river to a direction away from the bank. Loose stones, stones filled in gabion box, bricks, sand bags, bamboo piles, bamboo mats are used to make the spurs. Similarly embankments are constructed along the river bank to raise the level and stop the water spilling the bank and entering the villages. The embankments are made of earth.

Table:Proposed River Training Works

SN	Name of River	Chainage	Natural Hazard	Protection Measure
1	Seti Khola	0+300	Erosion	River Training Work
2	Kaule Khola	4+100	Erosion	River Training Work
3	Boski Khola	5+900	Erosion	River Training Work
4	Nanid Khola	11+570	Erosion	River Training Work
5	Tuni Khola	17+520	Erosion	River Training Work
6	Okadi Khola	27+300	Erosion	River Training Work
7	Jare Khola	31+250	Erosion	River Training Work

7.5.5 Property Acquisition and compensation

The road alignment mostly passes through the existing road track, forest area, cultivated land, human settlements, etc. In some places existing track should be widened and the land should be acquired from the public. People are very much interested to offer land for the construction of the road free of cost and some want handsome compensation for their property as well. The present government policy has made rather easier to acquire the land for the construction. The road law clarified in national law is rather strong enough to force the authority for land acquisition. But there is to be a committee to evaluate the value of land according to present government and market rate so that every owner will be satisfied and no dispute will occur during road construction.

7.5.6 Cost for Environmental Management Action Plan

Cost for Environmental Management Action Plan includes the cost incurred for mitigation measures and monitoring of the proposed project. Mitigation plan identifies the environmental mitigation essential to avoid or minimize adverse impacts and enhance beneficial impacts due to the proposed project on the physical, biological, socio-economic and cultural environment. The proponent will have the prime responsibility for implementation of above listed mitigation measures. Moreover, other adverse impacts that are not identified during this stage of study if later discovered during the construction and operation phases shall be explicitly mitigated or enhanced by the proponent on his/her own expense. The cost of major environment protection measures will be included in project cost estimate.

7.6 Related Legislations

7.6.1 Environmental Protection Act, 1997 and Environmental Protection Rules 1997

The Environmental Protection Act, 1997 (EPA) and the Environmental Protection Rules,1997 (EPR), enforced since June 1997, oblige the proponent to prepare and receive approval the IEE and EIA Reports of all projects/proposals as included in Schedule 1 and Schedule 2 of EPR, 1997 related with Rule 3. Section 3 to 6 of the EPA, 1997 and Rules 3 to 11 of the EPR, 1997, contain provisions on the approval process of the IEE report. Rule 12 of the EPR oblige the Proponent to comply with matters mentioned in the report and other conditions, if any, prescribed by the approving agency, i.e. the concerned agency (Ministry of Physical Planning and Works for this proposal). The Rule 13 obliges the concerned body i.e. MPPW for this Proposal, to conduct environmental monitoring. As per the environmental law, the Proponent should implement the environmental enhancement and mitigation measures as per Environmental Management Plan prepared in IEE or EIA. The Proponent is not required to prepare EMP for IEE study as per EPA and EPR. However, it could be prepared and implementation to mitigate adverse environmental impacts through pre-designed plan.

7.6.2 Local Self Governance Act (1999) and Rules (2000)

The Local Self Governance Act has been enacted to provide greater, administrative and finance autonomy to local bodies and facilitate community participation at the local level. The Local Self Governance Act, 1999 empowers the local bodies for the conservation of soil, forest and other natural resources and implements environmental conservation activities. Sections 28 and 43 of the Act provide the Village Development Committee (VDC) a legal mandate to formulate and implement programs related to the protection of the environment during the formulation and implementation of the district level plan. Sections 28, 43, 189 and 201 of the Act are of relevance and are attracted while implementing this EMP.

7.6.3 Land Acquisition Act, 1977 and Land Acquisition Rules, 1969

Land Acquisition Act, 2034 (1977) with amendment in 2049 (1993) guides the compulsory acquisition of land in the country. The Land Acquisition Act 2034 (1977) and the Land Acquisition Rules 2026 (1969) are the two main legal instruments that specify procedural matters of land acquisition and compensation. Government can acquired land at any place in any quantity by giving compensation pursuant to the Act for the land acquired for any public purposes or for operation of any development project initiated by government institutions (Section 3 and 4). The powers given under these sections are very broad as government is empowered to acquire any land in the name of public works. The interim Constitution of Nepal, 2007 in its Article 19 (2) directs the state to provide compensation for nay property requisitioned, acquired or encumbered by the State in implementing scientific land reform program or in public interest in accordance with law.

7.6.4 Labor Act, 1992 and labor Rules, 1994

Labor Act, 1992 (first amendment 1998) and Labor Rules, 1994 deals deal with manual labor. Clause 46 under Section 7 deals particularly with Construction industry. The Act defines working time as eight hours a day a weekend leave. A half an hour break should be given as snack and tea break before continuous work of maximum five hours. Attendance Registry should be maintained properly. Clause 27 to 32 under Section 5 gives details for occupational health and safety requirement to be maintained for labors. Child labor (below 14 years) is prohibited, and between 14 to 16 years of age should be given proper training before putting them in work. It calls for insurance and safety management of labors. It also directs to establish camp near temporary working sites with drinking water, food, sanitation and residential facilities if numbers of labors are fifty or more in construction projects. The Labor Rule, 1994 guarantees equal wage for male and female. It also lists the percentage of compensation for different types of accidents during work at site.

7.6.5 Soil and Watershed Conservation Act, 1982

For the conservation and management of watersheds of Nepal, the Soil and Watershed Conservation Act, 1982 was enacted. Section 3 of the Act empowers the Government to declare any area as a protected watershed area. Section 4 of the Act provides an authority to watershed conservation officer to implement the following works in protected watershed areas:

- Construct and maintain dam, embankment, terrace improvements, diversion channels and retaining walls;
- Protect vegetation in landslide-prone areas and undertake afforestation programs; and
- Regulate agricultural practices pertinent to soil and watershed conservation.

Under Section 10 of the Act, Watershed Conservation Officer has authority to grant permission to construct dams, drainage ditches, canals, cut privately owned trees, excavate sand, boulders and soil, discharge solid waste and establish industry or residential areas within any protected watershed.

7.6.6 Public Road Act,1974

Article 19 of the Act mandates the requirement of permission from the Department of Roads to carry out activities within the limits of the road boundaries. GON offices as per Article 29 have to submit a request for permission to the Department of Roads prior to the start of activities within the limits of the public roads.

7.6.7 Town Development Act, 1988

The Town Development Act of 1988 (Section 12.1) provides the legal basis for implementing the Land Reform (Land Pooling). The Act clearly states procedures and conditions to secure

landowners' agreement, government approval and project implementation. The Town Development Act, 1988 (2045B.S.) clearly explains mandatory procedures to be followed during preparation and implementation Land-Pooling. The process of land pooling begins when Town Development Committee itself or Land Management Sub-Committee formed under the Town Development Act, 1988, selects the area for pooling. The Land Management Sub-Committee (LMSC) constitutes of representatives of local land owners, various governmental line agencies, CBOs and local NGOs. LMSC takes all the decisions for land pooling. Local User Committee (US), CBOs and NGOs works at the grass root level assist the LMSC in preparing policies, implementation procedures and action plans to execute the Land-Pooling process. Land pooling may consist three major steps. In the first step scoping and discussions with landowners and tenants will be held and a feasibility study is carried out. In the second stage, survey, delineation of area, confirmation of infrastructures, decision on contribution policy and plotting of readjusted plots in the map will be carried out. In the final stage after the approval from concerned authority readjustment of plots on field and construction works will be carried out prior to the distribution of permanent land ownership to the owner.

7.6.8 Solid Waste Management Act, 2011

This act has set provisions as prime responsibility of the polluters to manage waste. Similarly, the act outlines the duties of the local government to take action against haphazard waste generation, disposal or collection and has penalizing provisions to those engaged in activities detrimental to the intentions of the Act.

CHAPTER 8: DETAILED PROJECT REPORT

8.1 Engineering Cost Estimate

Cost estimate of this project is prepared after finalization of the alignment, detailed survey and detailed engineering design. Costing is done according to the prevailing practice of Nepal with standard rate analysis of Government following the district rates and other sources of material, labour and equipment rates. Unit rates for most of the items are fixed by detail analysis while some unit rates for bridges and finishing works are fixed by the standard practice in such other studies. Similarly the quantity estimate is calculated from standard drawings and following prevailing practice and provided in Volume II

8.1.1 Construction cost

The construction cost is calculated in the basis of proper rate analysis and detailed quantity estimate and broken down into local and foreign currency components. It was broken down into direct cost, taxes, physical and price contingencies.

8.1.1.1 Rate Analysis

Detail analysis of rate is performed for earth works, retaining structures, side drains and pipe culverts work. Similarly detail analysis of rate is done for pavement works. Unit rate for per meter cost is used for bridges, culverts and causeway. The construction material is assumed that the road will be constructed stage wise. So, only the average cost for cement, pipe culvert and reinforcement is taken. It is assumed that other construction material will be used after the access is established to the site. Other miscellaneous unit rates are calculated based on the current practice and experience in the similar project. (Provided in Volume II)

8.1.1.2 Quantity estimate

Quantity estimate of different item is done to reflect the actual construction cost for economic analysis of the project. However some assumptions are also made for certain items detail procedure and method of calculation is presented below:

- Quantity calculation of earthwork is done with the help of typical cross section. Different cross sections are fitted in different chainagesafter field visit, geological reports and hazard analysis observations of particular stretches.
- After calculation of earthwork quantity, type of soil and rocks are also classified for different sections.
- In calculating the quantity of earthwork in OS, BMS, are assumed.
- Quantity of retaining structure is calculated according to the typical drawing developed.
- Type of side drains are designed and quantities are assumed on the basis of the design drain throughout the length of the alignment.
- Quantity of cross drainage structures is calculated based on the catchment area and flood forecast of ten years for pipe culvert and causeway.
- Length and number of bridges are fixed on 50 years design flood calculation; safe water-way length is fixed in field and suitability of particular structure.
- Quantity of pavement work is calculated based on cross section developed for highway of formation width of the adopted for the proposed road is 11m .
- Sub-Base is assumed to be 150mm, Base 250mm,Pavement 75mm.

8.1.1.3 Abstract of costs

After calculation of quantity and fixing unit rates for different items of work, abstract of cost is calculated for studied road alignment with incorporation of VAT of 13% and Contingencies 5%.

Summary of Cost

Chainage Km 0+000 - 32+680

Table:Summary of Cost

Summary of Cost

SN	Description of Works	Amount	Remarks
1	General Item	14,858,024.81	
2	Road Way Excavation	151,772,505.72	
3	Drain and Cross Drainage Work	236,853,299.66	
4	Structural works	83,528,973.17	
5	Pavement work	564,167,403.37	
6	Bio-Engineering	2,566,228.36	
7	Road Furnitures	26,617,047.17	
	Total	**1,080,363,482.26**	
	5%Contingency	**54,018,174.11**	
	5% Price adjustment Contingency	**54,018,174.11**	
	5% Physical Contingency	**54,018,174.11**	
	13 % VAT	**140,447,252.69**	
	Grand Total	**1,382,865,257.28**	
	Cost Per Km	**42,315,338.35**	

Abstract of Cost

Chainage Km 0+000 –32+680

Item: Abstract Of Cost

S.N	Description of works	Unit	Quantity	Rate	Amount	Remarks
1	**General Item**					
1.1	Insurance for the loss of damage to works, plant,material,equipment property and personnel injury or death, including third party insurance as per Contract Document (SS/SP-117)@1% of total cost	LS	1		5,775,308.71	
1.2	Provide and established comp for contractor including bath,toilet,and kitchen facilities, furnitures and well furnished as per details provided in special provision.(SS/Sp-109)	LS	1		1,443,827.18	
1.3	Provide ,operate and Maintain Quality Control Laboratory including equipment,accesoriesm and consumables for both fiel testing facilities and off site test with manpower as per Contract Document (SS/Sp-502/5011)	LS	1		2,021,358.05	
1.4	Maintenance of Existing Road to keep the road serviceable throughout the Contract Period.(SS/SP-107)	LS	1		577,530.87	
1.5	Provide and Installed Project Sign boards	Nos.	4	10000	40,000.00	
1.6	Relocation of services and repairing for existing infrastructure (houses, water supply pipes, Temple, Foot staircase, Foot trail etc) as instructed by engineer's.	Ps	1		5,000,000.00	
	Sub Total of General Item				**14,858,024.81**	

2	**Road Way Excavation**					
2.1	**Site Clearance**					
2.2	Clearing of grass, removing roots breaking sods, levelling the surface and disposal to 10m. (SS/SP-900)	Sq m	130,720.00	17.70	2,313,744.00	
2.3	Earth work excavation for Back cutting / Grade cutting in all type of soil and rock including disposal upto 10 m and lift upto 1.5 m etc. all complete (SS/SP-900)	Cu m.	836,680.47	121.00	101,238,336.87	
2.4	Formation of embankment including compaction in layers not exceeding 150 mm compacted depth, watering and haulage 10 m etc. all complete as per specification (SS/SP-900)	Cu m.	38,649.00	1,247.65	48,220,424.85	
	Sub Total of Road Way Excavation				**151,772,505.72**	
3	**Drain and Cross Drainage Work**					
3.1	Earthwork Excavation for Foundation of Drain in all type of soil and rock including disposal upto 10 m and lift upto 1.5 m etc. all complete	Cu m.	16,961.63	152.00	2,578,167.76	
3.2	Providing and Laying of Dry Stone Soling for foundation works of drain all complete works as mentioned in specification and directed by the Engineer	Cu m.	4960.65	2306.04	11,439,457.32	
3.3	Providing, preparing and installing formwork for foundation and footings including necessary supports and removing after completion all complete. (SS/SP-	Sq m	4540.80	663.64	3,013,456.51	

	1800)					
3.4	Providing and Placing machine mixed cement concrete M15/40 for the foundation and footing etc. including compaction, curing, testing all complete. (SS/SP-2000)	Cu m.	2393.95	11953.88	28,616,991.02	
3.5	Providing and Placing machine mixed cement concrete M20/40 for the foundation and footing etc. including compaction, curing, testing all complete. (SS/SP-2000)	Cu m.	4841.96	13148.30	63,663,542.66	
3.6	Providing and laying reinforcement including cutting, bending, binding, fixing in position etc. all complete. (SS/SP-2000)	Mt	126.310	136557.24	17,248,544.98	
3.7	Providing and laying Random Rubble Masonry in cement/ sand (1:4) mortar including scafolding , curing , preparation of mortar etc.complete, masoned height 0.5m , lead 30m	Cu m.	11092.05	9843.34	109,182,819.44	
3.8	Carry out backfilling works behind the structures with approved suitable material obtained from Structures excavation including haulage , spreading in layers, watering and compaction complete as per specifation and engieer's Instruction;	Cu m.	1042.15	877.71	914,705.47	
	Sub Total of Drainage & Cross Drainage works				**236,853,299.66**	
4	**Structural works**					

4.1	Earthwork Excavation for Foundation of Retaining Structures in all type of soil and rock including disposal upto 10 m and lift upto 1.5 m etc. all complete	Cu m.	12870.40	152.00	1,956,300.80	
4.2	Providing and Laying of Dry Stone Soling for retaining structure foundation works all complete works as mentioned in specification and directed by the Engineer	Cu m.	202.68	2,306.04	467,388.18	
4.3	Providing and Placing machine mixed cement concrete M15/40 for the foundation and footing etc. including compaction, curing, testing all complete. (SS/SP-2000)	Cu m.	810.72	11953.88	9,691,249.59	
4.4	Supply of Machine Made Gabion boxes / mattresses with diapharagms including rolling, cutting and weaving all complete as per specification. Salvage wire 3.9mm, Mesh Wire 3.0mm and Hexagonal Meshsize 100x120 mm all complete as per Engineers direction	Sq. m	48940.00	231.21	11,315,417.40	
4.5	Providing and filling stones into Gabion crates all complete as per specification.(SP 2400)	Cu m.	9000.00	2509.99	22,589,910.00	
4.6	Supply and laying of geo-textile behind retaining structures, abutment walls, head walls of causeways and pipe culverts etc all complete.(3110)	Sq. m	6555.00	205.91	1,349,740.05	
4.7	Providing and laying Random Rubble Dry Masonry work including scafolding	Cu m.	8304.90	4001.85	33,234,964.06	

	etc.all complete, masoned height 0.5m , lead 30m					
4.8	Carry out backfilling works behind the structures with approved suitable material obtained from Structures excavation including haulage , spreading in layers, watering and compaction complete as per specifation and engieer's Instruction;	Cu m.	3331.40	877.71	2,924,003.09	
	Sub Total of structures				**83,528,973.17**	
5	**Pavement work**					
5.1	Preparation of Sub Grade by grading, watering & compaction for upgrading of the road (filling or cutting depth up to 10 to 20 cm) in Gravel and Boulder mixed soil. (SS/SP 1003)	Sq. m	403045.40	115.48	46,543,682.79	
5.2	Providing, laying spreading, watering leveling and compaction of natural sand gravel sub base grading as per table 12.1 of standard specification with necessary lead up to 10m all complete (SS/SP 1201)	Cu m.	62749.48	3,122.45	195,932,113.82	
5.3	Providing, laying spreading, watering leveling and compaction of crusher run base course material grading of standard specification lead up to 10m (SS/SP - 1202)	Cu m.	47732.23	3,591.57	171,433,645.30	

5.4	Providing and spraying bituminious Prime coat MC30/MC70 including cleaning the road surface using wire,brushes, broom etc. before applying prime coat (SS-1301,1302).	litre	248255.00	181.53	45,065,730.15	
5.5	Surface Dressing, Laying of single / double / multiple bituminous coats for surface dressing using river single/chips including cpaction. Bitumen binder for surface dressing all complete (1301, 1303)	litre	37762.10	155.91	5,887,489.01	
5.6	Surface Dressing, Laying of single / double / multiple bituminous coats for surface dressing using river single/chips including cpaction. Cutter for bitumen grade 80/100 all complete (1301, 1303)	litre	610854.42	119.08	72,740,544.33	
5.7	Providing and mixing antistripping agent all complete as per specification	kg	3559.40	244.91	871,732.65	
5.8	Surface Dressing, Laying of single / double / multiple bituminous coats for surface dressing using river single/chips including cpaction. Chippings for surface dressing for 1st and or 2nd coat size all complete.	ton	8456.81	3,038.08	25,692,465.32	

	(1301, 1303)					
	Sub Total of Pavements				**564,167,403.37**	
6	**Bio-Engineering**					
6.1	Earthwork in slope trimming, excavation of trench including spoil disposal at specified site.	Sq. m	615.00	119.70	73,615.50	
6.2	Supply and Planting rooted grass slips on slopes <45° including preparation of slips on site. Operation includes digging planting hole to a max of 5 cm depth with metal rod or hardwood peg, depending on nature of soil. The planting drills should be spaced 10 cm apart.	Sq. m	380.00	268.99	102,216.20	
6.3	Supply and Planting containerised tree and shrub seedlings, including pitting, transplanting, composting and mulching, on slopes 30-45°. Pit size 30 cm diameter * 30 cm depth. Mix compost with soil and backfill into pit, to 1/4 of pit volume.	No	1,847.00	38.04	70,259.88	
6.4	Supply and planting bamboo/ nigalo rhizome including wrap the root ball in damp hessian, digging a hole and backfill same, mulching, etc. all complete as per specification.	No	2,744.00	60.66	166,451.04	
6.5	Supply, Preparation and planting of live pegs of selected species of minimum 1 m length to 0.5 m	Rm	3,640.00	176.88	643,843.20	

	depth into hard ground *for brush layering/ palisades*. Pegs spaced at 5 cm centres within rows, with 5-20 cm between rows, and interwoven with vegetation.					
6.6	Supply of Machine Made Gabion boxes / mattresses with diapharagms including rolling, cutting and weaving all complete as per specification. Salvage wire 3.9mm, Mesh Wire 3.0mm and Hexagonal Meshsize 100x120 mm all complete as per Engineers direction	Sq m.	1,782.00	231.21	412,016.22	
6.7	Providing and filling stones into Gabion crates all complete as per specification.(SP 2400)	Cu m.	330.00	2,509.99	828,296.70	
6.8	Supply and laying of geo-textile behind retaining structures, abutment walls, head walls of causeways and pipe culverts etc all complete.(3110)	Sq m.	322.00	205.91	66,303.02	
6.9	Earthwork Excavation for Foundation of Retaining Structures in all type of soil and rock including disposal upto 10 m and lift upto 1.5 m etc. all complete	Cu m.	528.60	152.00	80,347.20	
6.10	Carry out backfilling works behind the structures with approved suitable material obtained from Structures excavation including haulage , spreading in layers, watering and compaction complete as per specifation and engieer's Instruction;	Cu m.	140.00	877.71	122,879.40	
	Sub Total of Bio Engineering Works				**2,566,228.36**	

7	**Road Furnitures**					
7.1	Supplying and erecting sign in place including 50cm dia. Steel tube, 2mm, thick steel plate, cement concrete, painting, writing and supporting steel angle nut and bolit etc. complete. (SS/SP-1501)	No	-	1,576.74	-	
7.1.1	a) 60cm. Dia. Circular, 60cm. equilateral traingle and 60cm.x 45cm. rectangular shaped sign (single post).	No	27.00	1,790.17	48,334.59	
7.1.2	b) 1.2m.x 0.75m. Size bigger traffic sign with back support and two or more post.	No	7.00	4,830.90	33,816.30	
7.2	Supplying and fixing in place R.C.C. delineator and guard post including excavation, back filling, painting and erection etc. all complete as per drawing. (SS/SP-1504)	No	608.00	1,360.93	827,445.44	
7.3	Supplying and applying paint for road marking including cleaning, watering, brooming etc. all complete (10 cm wide strip) (SS/SP1502)	M.	60,555.30	51.06	3,091,953.61	
7.4	Supplying and placing R.C.C kilometer post including excavation, back filling, painting and writing etc. all complete as per specification (SS/SP-1503)					
	a) Standard Kilometer post (Placed at each km)	No	27.00	3,615.76	97,625.52	
	b) Bigger Kilometer post (Placed at each 5 km)	No	7.00	5,145.73	36,020.11	

7.5	Provide and erecting "W" metal beam crashbarrier comprising of 3.43mm thick corrugated sheet metal beam rail, 70cm above road/ground level,fixed on ISMC serises channel vertical post, 150*75*5 mm spaced 2m c/c,1.8m high,1.1m below ground/road level,all steel paetsand fitment to be galvanized by hot dip process,all fittings to confirm to IS 1367 and IS 1364,metal beam rail to be fixed on the vertical post with a spacer of chaneel section 150*75*5mm 330mm long, all complete	Rm	3,160.00	7,114.51	22,481,851.60	
	Sub Total of Road Furniture				**26,617,047.17**	
	Total				**1,080,363,482.26**	
	5%Contingency				**54,018,174.11**	
	5% Price adjustment Contingency				**54,018,174.11**	
	5% Physical Contingency				**54,018,174.11**	
	13 % VAT				**140,447,252.69**	
	Grand Total				**1,382,865,257.28**	
	Cost Per Km				**42,315,338.35**	

8.1.2Maintenance cost

Estimation of benefits arising from the implementation of the road project requires comparison of "with project" situation with "without project" situation. The later, is therefore, critical in that it determines the level from which incremental benefits from the implementation of the project are derived. Presently "without project" situation, there is an existing road in the proposed alignment. The expenditures on maintenance activities in an existing road condition are not considered. Standard maintenance measures have been suggested for "with project" situation.

8.2 Bill of Quantities

Each items were clearly described and corresponding clauses of the standard and special specifications were referenced to allow the contractor to easily find the corresponding specification. The BOQ were broken down into different types of works and were clearly provide for VAT and contingencies. Detail information about bill of quantities are (provided in Volume III)

8.3Programme Preparation

This programme includes the duration of activities and critical milestones on the following activities.

- **Pre-construction activities of the implementing agency:**
  Consulting Firm and Contractors will be invited to submit their Expression of Interest EOI to provide consultancy service and construction work respectively. And Eligible consulting and contractors will be selected for construction works.

- **Consultancy services:**
  Selected consulting firm will be responsible for providing consultancy service for the construction of Road Projects. They need to set up camp office and necessary man-powers to site for quality and time control of construction. They shall be responsible for supervision of construction as per drawings provided and contract technical specifications. They shall be responsible for verification of Bill of Quantities prepared by the contractors and they shall provide necessary guidance and support to contractors for completion of construction work in time.

- **Construction of works:**
  Selected contractors will be responsible for construction of works maintaining quality and in given time schedule. They shall set up camp in project site, provide necessary man-powers, equipments and materials in project site. They shall be responsible for preparing work schedule of construction works and they need to inform consulting firm about this. They shall be responsible for assuring quality of works to consulting firm as per drawings and contract technical specification. They shall be responsible for preparing Bill of Quantities and need to submit to consulting firm for it's verification. Variation order should be taken from client incase of variation in construction works are found. Therefore, construction company is wholly responsible for completion of construction works in specified time and they need to co-operate with client and consulting firm during whole construction period,

8.4 Project Objectives and Scope Development

The development of the project objectives are based on the sector policies of Government of Nepal requirements. A logical framework is used to develop the goals and objectives. Detail information about project objectives and scope development is given below:

Table: Project Objectives and Scope

Narrative Summary	Objectively Verifiable Indicators (OVI)	Means of Verification (MOV)	Key Assumptions
Goal To improve and provide greater accessibility to urban populations centers and connect them to the national road network and economic centers through 2 Lane Road	• Influenced population will get access to road service and economic centers from the end of 3rd year of construction through this route. • Local agricultural production will get exported to major market centers in huge amount from the end of 3r year of construction.	• House hold survey • Major market centre survey • Origin and Destination Survey	• Private transport entrepreneurs will provide good transportation system. • Department of Road will provide proper maintenance of road timely.
Purpose Development of the Trade Route Syangja	• It will be trade route in distance to join Syangja and Parwat than other roads. • It will save transportation costs and time of passengers and goods and benefits will be increased. • Economic growth rate will be increased.	• House hold survey • Transportation Costs Records • Co-operative accounts of users. • Economic growth rate record.	• Efficient movement of different vehicles. • Co-operatives will be successfully established.
Outputs 1. Upgradation of road connecting the Syangja District 2. Connecting previously unconnected	• There will be good movement of passengers and goods even in monsoon season. • All urban people will have access to	• Work completion records • Origin and destination survey	• Construction work will be completed in time by contractor. • Timely maintenance of

Narrative Summary	Objectively Verifiable Indicators (OVI)	Means of Verification (MOV)	Key Assumptions
urban areas to the district headquarters	district headquarters. • Transportation will be increased by 6%	• Transportation of goods record.	Road. • Efficient movements of vehicles.
Activities 1. Procurement of road construction equipment and materials 2. Procurement of skilled and unskilled workers for the actual construction works 3. Mobilization of construction team 4. Set-up of camp at various chainages 5. Mobilization of construction equipments, vehicles and other necessary tools to site 6. Supply of construction materials to sites. 7. Preparation of work schedule with detail work description 8. Layout and then construction in field as per drawings and specification 9. Assure quality of works to consultant or client. 10. Preparation of variation order and BOQ and its submission to consultant or client	**Means** • Construction costs for 1st year: All construction works including different construction items, insurance of workers, bio-engineering works, contingencies (including VAT) • Construction costs for 2nd year: All construction work including different construction items, insurance of workers, bio-engineering works, contingencies (including VAT) • Construction costs for 3rd year: All construction work including different construction items, insurance of workers, bio-engineering works, contingencies (including VAT)	**Costs** • As per BOQ • As per BOQ • As per BOQ	• Full cooperation of the stakeholders at the district and local levels. • Timely procurement of budgets for construction by concerned ministries and departments. • Timely procurement of construction works • Proper check of quality of works • Timely monitoring and evaluation of works by consultants or clients. • Proper verification of bill of quantities and variation order.